Sept. 12, 1967 M. D. HOSTETTER 3,341,253

RIPPER APPARATUS AND METHOD OF USING SAME

Filed Nov. 13, 1964

3 Sheets-Sheet 1

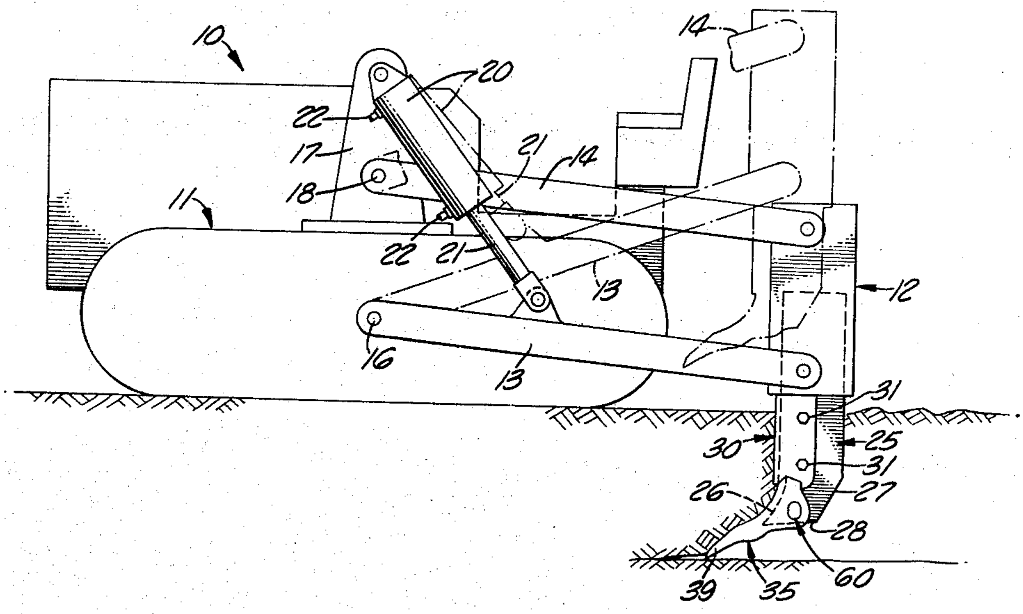


FIG. 1.

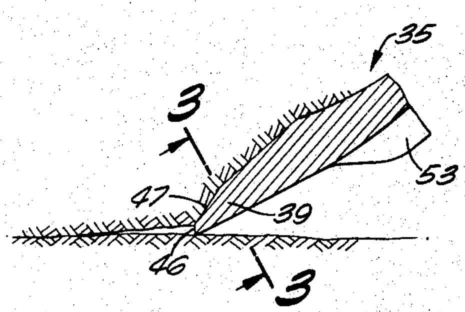
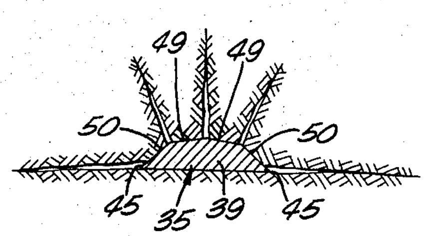


FIG. 2.

FIG. 3.



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RIPPER APPARATUS AND METHOD OF USING SAME

Filed Nov. 13, 1964 3 Sheets-Sheet 2

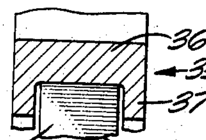

FIG. 6.

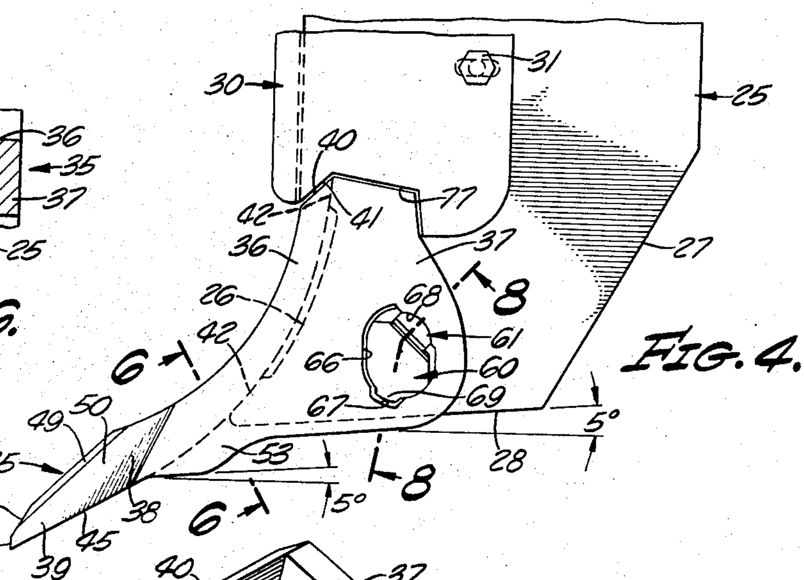

FIG. 4.

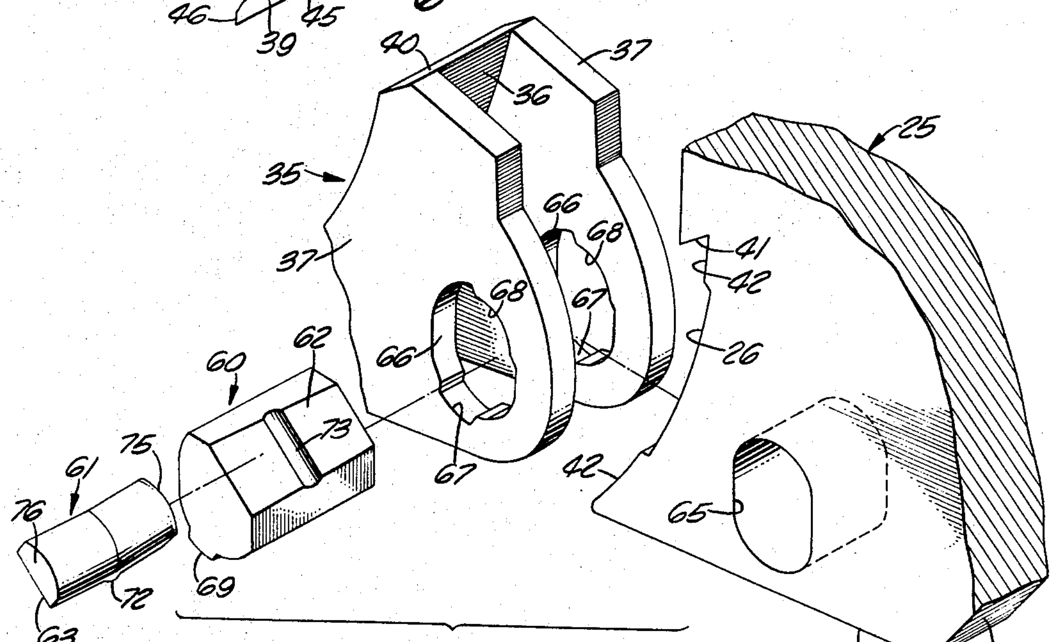

FIG. 5.

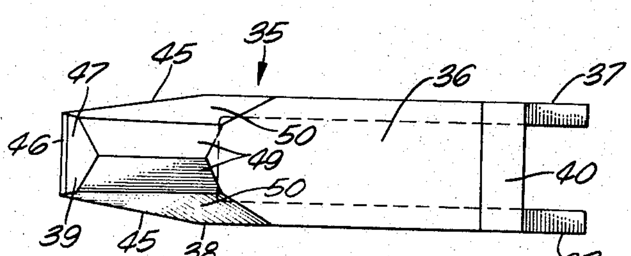

FIG. 7.

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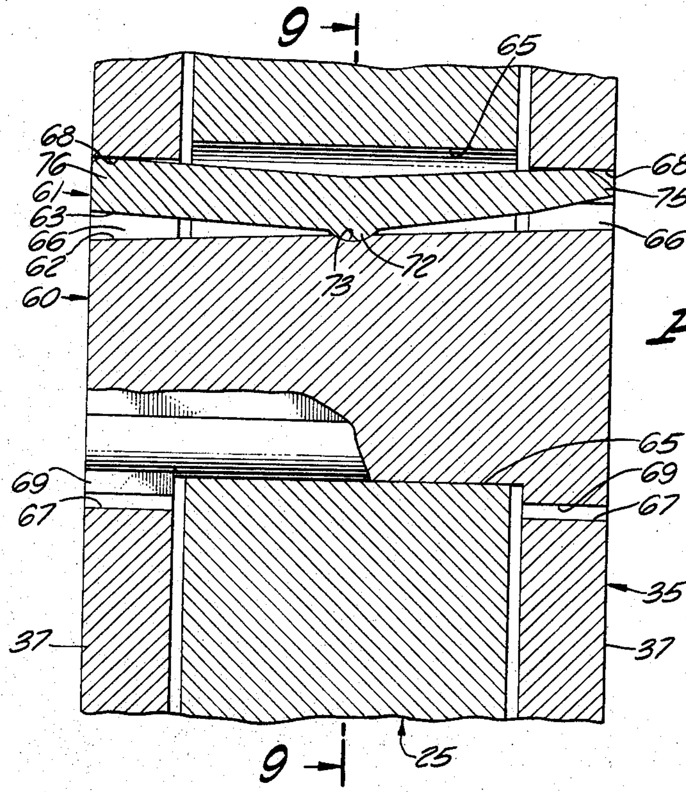
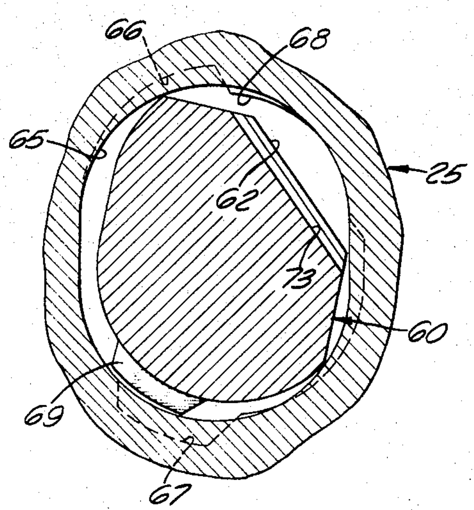


FIG. 8.

FIG. 9.



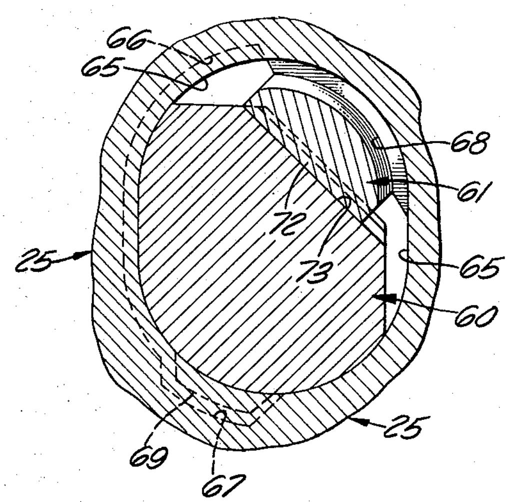


FIG. 10.

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United States Patent Office

3,341,253

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RIPPER APPARATUS AND METHOD OF USING SAME

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Filed Nov. 13, 1964, Ser. No. 410,856
30 Claims. (Cl. 299—10)

This invention relates to ripping of terrain formations and more particularly to an improved crawler type traction means and to an improved ripper adjustably coupled thereto and designed to penetrate the terrain automatically both with and without the use of power-applied penetrating forces in addition to those generated as an incident to forward movement of the traction vehicle. The invention also includes an improved shank, tooth and retainer means, taken separately and in combination.

Modern day excavating operations present serious problems as respects provisions of satisfactory and effective means for loosening widely varying types of terrain sufficiently for handling by earth-handling equipment. Many proposals and constructions have been presented heretofore intended to cope with these problems but all are subject to serious shortcomings and defects sought to be obviated by the present invention. Typical of these problems and shortcomings evidenced by prior equipment are the following.

For example, it is found that the penetration of ripper equipment into rock or compacted formations is difficult and requires allocation of substantial portions of the available power to mere advance of the hauling equipment. Additionally and seriously, power applied in efforts to press the ripper into the ground, according to prior proposals, invariably materially reduces the tractive effort effectiveness of the hauling vehicle since the reaction to the penetrating forces serves to lift the vehicle away from the ground. Furthermore, it is found that the application of power-driven penetrating forces must be continued even after the ripper has been forced to a desired depth in order to keep the ripper teeth from again rising out of the surface.

An additional defect is that prior ripper equipment has been so constructed that the ripper tooth is not uniformly and properly postured relative to the horizontal when adjusted to different operating levels with the result that the tooth is not uniformly efficient in its various adjusted positions.

Another shortcoming of prior ripper equipment has been the lack of a ripper tooth having acceptable and satisfactory life and so designed as to have a wear pattern corresponding generally to the surface contour of the new tooth with the result that prior ripper teeth do not retain their shape and contour as wear progresses in use.

Typical ripper teeth as heretofore commonly designed are characterized by a relatively short forward pointed end in combination with a triangular socket opening rearwardly and adapted to telescope over a complementally shaped triangular nose piece of the supporting shank. Many problems are involved in the manufacture and use of such a tooth. These include the difficulties involved in the manufacture by casting or forging the mounting sockets of the teeth within acceptable tolerance variations with the result that many teeth have sockets even too small for proper assembly over the nose piece or are so large as to be loose and ill-fitting. In consequence, many attempts have been made to provide an effective means for holding the tooth locked in a desired position on the nose piece.

A further and serious shortcoming of prior tooth design involves insurmountable problems in the proper heat treatment to avoid locking in severe stresses as an incident of heat treatment. These problems in many instances, are closely connected with the aforedescribed triangular socket design which is unavoidably associated with widely varying wall thicknesses and "heat reservoirs" in the thicker portions of the tooth. In other words, it is found that portions of the tooth walls forward of the socket cool much more slowly during quenching than do other portions of the tooth and constitute heat reservoirs. These cause serious internal stresses which serve to weaken the tooth structure and lead to its premature failure in service. Additionally, the results of heat treatment essential to the desired hardening for greater wear and abrasion resistance vary widely and these constitute another important factor deterrent to long service life.

Still another deficiency of prior tooth design is the lack of sufficient relief on its underside with the result that the tooth rides on and slides over the top surface of freshly completed ripping similarly to a sled runner on snow and this action prevents the tooth from penetrating.

Other shortcomings of prior designs concern the contour of the shank employed to seat the tooth. Thus prior designs typically employ a massive shank structure terminating at its lower end in a forwardly-projecting relatively small cross-section triangular nose piece over which the tooth telescopes. This nose piece must be kept small to avoid the need for a tooth of excessive angle, size and cost. The brutal stresses to which the assemblies are subjected must be transmitted across the connection of the nose piece with the shank. Owing to the small dimensions imposed on the shank structure by the tooth design, it is common experience for the nose piece to break off either at its juncture with the shank proper or in the area of the hole for the tooth retainer means which hole or passage weakens the nose piece structure.

Still another shortcoming of prior nose piece designs is the provision of surfaces thereon intended to be complemental to the interior surfaces of the hollow tooth. Imperfections and tolerance variations in both of these interfitting sets of surfaces unavoidably lead to ill-fitting teeth; nonuniform distribution of stresses on the two structures; malfunctioning, if not nonfunctioning, of the retainer pin; loss of teeth in use; and the premature failure and loss of the tooth, shank, nose piece, and retainer pins while the ripper is in use.

Another general source of dissatisfaction in prior tooth and shank assemblies involves the retainer means provided for holding the teeth detachably assembled to the shank. A great variety of designs have been proposed heretofore but all fail to meet desirable objectives. Brutal forces are involved and only the most rugged type of structure capable of withstanding extreme shock loads and the most severe corrosion and abrasion conditions can be tolerated. Threaded fasteners of any type have long been considered unacceptable for many reasons well known to those skilled in this art. Many attempts have been made to provide cooperating retainer members depending upon resiliency of the constituent materials in combination with interlocking configurations of the tooth and shank to hold the parts assembled, yet capable of being disassembled and reassembled with a minimum of difficulty and loss of time. For the most part, proposals utilizing resiliency of either metallic or nonmetallic materials, while overcoming certain defects of other constructions, are nevertheless subject to other shortcomings sought to be obviated by the present invention.

The present invention avoids the foregoing and other shortcomings of prior designs in a simple and highly efficacious manner. For example, both the ripper assembly and the traction vehicle employed in its use are so constructed as to take advantage of very substantial forces available as the new ripper is advanced through the terrain to increase the traction effectiveness of the traction vehicle. Thus, the greater the load forces acting on the ripper tooth the greater is the available tractive effort because substantial portions of forces acting o nthe tooth act to increase the weight of the traction vehicle thereby increasing its tractive effectiveness rather than to decrease it as typically occurs in prior designs. As herein illustrated, this is accomplished using a parallelogram linkage to interconnect the ripper frame proper with a forward portion of a crawler type traction vehicle and including suitable locking means for anchoring this linkage rigidly in a desired adjusted position. The locking means may comprise hydraulically operated cylinder means having one end pivotally anchored to the tractor frame and the other end to the linkage.

The invention ripper assembly just described includes a special tooth and mounting shank so arranged and contoured as to be self-penetrating even in the hardest formation until further penetration is precluded by use of the lock-out mechanism. The tractive effectiveness of the vehicle increases automatically as penetration of the tooth increases thereby providing simple means for loading the vehicle to a maximum degree concurrently with utilization of the weight of ripped material to increase effective traction. Once this maximum effective operating depth is ascertained the ripper can be locked rigidly in this operating condition as it continues to move forward in maximum efficiency operation.

The parallelogram linkage assures support of the ripper tooth or teeth at the proper and most efficient operating angle irrespective of the depth at which it is desired to operate. Closely associated with this feature is the design of the underside of the tooth and supporting shank in such manner as to preclude the possibility of these surfaces riding on the newly formed surface of unripped material. Adequate clearance between these opposed surfaces assures the continuance of this highly important condition as the tooth wears in service.

The ripper tooth itself includes many novel features as does the supporting shank. The tooth of this invention has no hollow portions and is contoured with maximum attention to avoid heat reservoirs so detrimental to the uniform and proper heat treatment of the tooth with substantial no locked-in internal stresses. To this end the tooth has an elongated arcuate main body slab provided along its opposite upper lateral edges with integral mounting flanges positioned closely against the opposite sides of a massive slab-like mounting shank. Substantially one-half of the forward portion of the main body of the tooth is unsupported and extends downwardly and forwardly from the foremost corner of the shank. This tip end is specially contoured and includes a plurality of edges and faces so disposed to the horizontal as to produce multiple cleavages into the formation being ripped along predetermined shear planes selected for maximum efficiency ripping. These include edges and surfaces disposed to shear the formation horizontally immediately in advance of the path of travel as well as laterally to either side thereof and additionally, in radial planes diverging upwardly from the toe of the tooth. These shear planes continue to be opened progressively through the formation well in advance of the tooth itself with the result that material passing rearwardly over the surfaces of the tooth is loose and acts on the tooth under a pressure imposed largely by its own weight with the result that wear and abrasion on the tooth surfaces is reduced to a minimum.

Closely associated with this matter of reduced wear on the tooth toe is the fact that the surface of the main body rearward of the toe is relieved to a slight extent. Under moist operating conditions this relieved area becomes packed with wet material to provide a protective layer

safeguarding the tooth itself against wear so long as the layer is present. Even under dry conditions wear on the surface is greatly reduced by reason of the relieved condition.

The upper end of the main body is beveled upwardly and rearwardly and seats within a complementally shaped notch provided on the forward face of the supporting shank. Accordingly, much of the pressure imposed across the pointed end of the tooth is transmitted by compressive action along the body and upwardly and into the shank thereby materially reducing the load required to be absorbed by the lower tip end of the shank.

Featured also by the invention is novel foolproof high-strength retainer pin means of unique shape. This retainer pin assembly is formed in two parts of massive cross-section one of which is much thicker than the other and is provided at its opposite ends with lugs projecting across the opposite rim ends of a seating bore therefor crosswise of the shank. The other retainer member is bowed lengthwise of itself and is made of highly tempered resilient material capable of storing high-energy tensile forces for long periods while in assembled condition. Both pins are provided with facing flat surfaces which taper in opposite directions to facilitate assembly within the shank bore and cooperating to facilitate storing of the aforementioned tensile stresses which are utilized to hold the ripper tooth firmly seated at all times, and additionally, to provide powerful frictional engagement between certain surfaces to prevent disassembly of the retainer pin means.

Featured also by the retainer pin means is the non-circular shape of the receiving openings for the retainer means and the slightly offset registry of the openings in the tooth flanges with the shank bore in such manner that the pins in assembled stressed condition, are effective to urge the tooth upwardly and rearwardly against the forwardly sloping tooth seat formed on the shank. Positive and accurate seating of the tooth in this position is further facilitated and assured by reason of provision for lateral movement of the pins relative to one another along their mid-length fulcrum to provide automatic self-centering and accommodating compensation for tolerance variations in the several components; additionally accurate seating is facilitated by relief of the seating face on the shank in such manner as to provide two seating pads crosswise of the shank edge.

Still another feature is the provision of a protective boot for the shank embracing the forward edge and side faces of the shank.

This protective boot is shaped to interlock with the upper perimeter edges of the tooth with the result that the retainer pin for the tooth serves additionally to aid in holding the boot in its normal operating position. Providing further support for the boot are one or more light fastener means constructed to hold the boot in position while the tooth itself is being removed and reassembled and also supplementing the tooth retainer pin in holding the boot in assembled position.

These and other more specific objects will appear upon reading the following specification and claims and upon considering in connection therewith the attached drawing to which they relate.

Referring now to the drawing in which preferred embodiment of the invention is illustrated.

FIGURE 1 is a side elevational view showing essential details of one preferred embodiment of the invention ripper operatively associated with a crawler type traction vehicle while in the process of ripping a rock formation;

FIGURE 2 is a fragmentary longitudinal view on a large scale taken through the forward end of the ripper tooth;

FIGURE 3 is a transverse sectional view taken along line 3—3 on FIGURE 2 showing typical cleavage planes as viewed crosswise of the ripper tooth;

FIGURE 4 is a fragmentary side elevational view on an enlarged scale through the lower end of the invention ripper shank and tooth assembly;

FIGURE 5 is a fragmentary exploded view of FIGURE 4;

FIGURE 6 is a fragmentary transverse view through the tooth taken along line 6—6 on FIGURE 4;

FIGURE 7 is a top plan view of the tooth per se;

FIGURE 8 is a transverse sectional view taken along broken line 8—8 of FIGURE 4;

FIGURE 9 is a cross-sectional view taken along line 9—9 on FIGURE 8; and

FIGURE 10 is a cross-sectional view similar to FIGURE 9 but showing the larger of the retainer pins in the process of being installed.

THE STRUCTURE GENERALLY

Referring initially more particularly to FIGURE 1, there is shown a crawler tractor **10** equipped with the usual track laying treads **11**. Suitably secured across the rear end of this traction vehicle in a suitable massive ripper frame **12** preferably connected to the vehicle through pairs of parallelogram linkages **13**, **14** located along either side of the vehicle. The forward end of lower link **13** is preferably connected to a suitable draft connection intermediate the opposite ends of the tractor, such as, the master central draft bar **16** customarily provided on this type of vehicle. The forward end of the upper link **14** is connected to the main tractor frame as by means of a bracket **17** and a pivot pin **18** supported thereby. The rear ends of the two links are similarly connected to pivot pin means provided at vertically-spaced points on ripper frame **12**.

Manually controlled power-operated means for holding the ripper elevated to an inactive position, such as indicated in the broken line showing of FIGURE 1, comprises a pair of hydraulic cylinders **20** located along either side of the tractor. Their upper ends are pivotally connected to bracket **17** whereas the piston rod **21** of each is pivotally connected to one link of the associated parallelogram linkage. It will be understood that flexible hose connections **22**, **22** extend from the opposite ends of cylinders **20** to convenient control means accessible to the vehicle operator and by which pressurized liquid can be supplied to and exhausted from the opposite ends of the cylinder as necessary to raise or lower the ripper under load conditions and to lock it in any desired retracted or operating position.

THE RIPPER TOOTH

The ripper tooth, designated generally **35** forming a particularly important component of the invention, is cast or forged in one piece from suitable material, as steel, and is heat treated in a manner well known to those skilled in this art to impart to its hardness, toughness and excellent wear and abrasion resistant qualities. As best appears from FIGURES 4 to 7 the tooth comprises an arcuate shaped main body **36** and a pair of identical side flanges **37**, **37**. Main body **36** is of substantially uniform thickness except that its thickness is slightly greater through the heel portion **38** of its toe or tip **39**. The upper end **40** of the main body is beveled at about a 45 degree angle to seat within a correspondingly shaped notch **41** formed crosswise of the upper end of seat **26** in shank **25**. If desired and before heat treating the shank, surface **40**, as well as those portions of the rear side of the main body in seating contact with pads **42**, **42** of shank face **26**, may be given a light surface finish. Pads **42**, **42** may also be given a finish to provide accurate seating surfaces for the tooth when assembled to the shank.

Heel and toe portions **38**, **39**, respectively, of the advance end of the ripper tooth, are specially contoured to serve important functions. In general, the tip end of the tooth tapers downwardly transversely thereof as well as in a lengthwise direction. Its opposite lateral edges **45**, **45** also taper toward the square cut nose end **46** and the latter tapers upwardly and rearwardly in two stages, the latter **47** of which is inclined less acutely to the vertical than the lower substantially vertically disposed slower stage. The upwardly facing surfaces of the tip also include a pair of pitched planar surfaces **49** meeting along the upper longitudinal center of the tooth and a pair of relatively acutely-inclined planar surfaces **50**, **50** sloping downwardly from the remote lateral edges of the pitched planar surfaces **49**, **49**. The two pairs of surfaces **49**, **50** may be viewed as having the shape of a hip roof.

The described toe surfaces, and particularly the longitudinal ridges therebetween, together with the converging lateral edges **45**, **45** and the sharp-edged nose piece **46**, cooperate in producing concentrated stresses along shear planes so disposed as to facilitate multiple cleavages progressing in predetermined directions in the formation being ripped. This will be best understood by reference to FIGURES 2 and 3 showing the principal planes of cleavage in a typical homogeneous rock formation.

Thus, referring to FIGURES 1 and 2, it will be seen that one wedge-shaped cleavage proceeds forwardly in a horizontal direction from the forward end of the nose piece. Simultaneously, other planes of cleavage proceed outwardly and upwardly, as will be best seen from FIGURE 3. Thus, the forwardly tapering edges **45**, **45** cooperate with the forward edge of the nose piece in extending the horizontal cleavage to either side of the ripper tooth thereby greatly amplifying the cleavage initiated by the nose of the ripper. At the same time the longitudnal ridges between surfaces **49** and **50** as well as the central ridge longitudinal of the nose piece form upwardly diverging cleavage planes extending at an angle to one another in the manner shown in FIGURE 3.

Initially very considerable power is required to initiate the planes of cleavage but once these are started the shearing action through the brittle rock proceeds rapidly under high mechanical leverage and is further facilitated by the powerful wedge actions produced by the tapering surfaces **46**, **47**, **50** and **49** on rock passing over portions of the nose piece rearward of its advance end. Powerful camming action produced by these acutely inclined surfaces will, therefore, be understood as cooperating with the ridge edges themselves in a highly efficient manner to cause the rock formation to break up as it flows smoothly rearwardly over the tooth surfaces. Inasmuch as the rock normally breaks up in large pieces there is relatively slight contact with the tooth as the rock flows therepast. For this reason, as well as the fact that the top surface of the main body in the area overlying the rear end of the nose piece is relieved or undercut, there is very little wear on the upper two-thirds of the main body. In fact, in most terrain, particularly when moist, the relieved surface of the tooth main body becomes coated with a layer of compacted material with the result that no wear occurs to the coated surface under these conditions.

Likewise the opposite sides, and particularly the under surface of the tooth, are not subject to any except slight wear owing to the design of the tooth and the ample relief provided rearward of its nose. Side flanges **37**, **37** preferably extend downwardly below surface **28** of the shank sufficiently to protect this surface from wear. The foremost lower corner of the side flanges are contoured as indicated in order to provide reinforcing at **53** (FIGURE 4) for the nose piece and additionally to provide a short skid for the tooth while withdrawing rearwardly from a ripping operation. It will also be noted that the relatively flat forward corner of the shank terminates in the general area of but above reinforcing webs **53**. Accordingly, webs **53** will be understood as acting as skids and additionally as reinforcing for the tooth at this point thereby preventing break-off of the advance end of the tooth under severe operation conditions.

THE RETAINING PIN MEANS

Referring more particularly to FIGURES 5 and 8 to 10, there will be described the two-piece retaining means used to hold tooth **35** forcibly and resiliently seated against pads **42**, **42** and with its upper beveled end **40** firmly pressed against shank surface **41**. This retaining means comprises a relatively massive straight non-flexing member **60** and a relatively smaller longitudinally-bowed resilient key **61**. These members have juxtaposed flat faces **62**, **63**, respectively, tapering in opposite directions in their assembled positions thereby materially facilitating assembly and disassembly.

The retaining pins **60**, **61** are mounted in a transverse opening or bore **65** through the shank with their ends terminating in aligned openings **66**, **66** through tooth flanges **37**, **37**. It is pointed out and emphasized that tooth openings **66**, **66** are slightly disaligned with the shank opening **65** in a direction offset slightly forwardly from the center of openings **65**. All openings preferably are generally elliptical in cross-section with the major axis disposed substantially vertically. Openings **66**, **66** are provided with a radial notch **67** along their lower forward corners and with a low-height arcuate boss **68** projecting inwardly from their diametrically opposed corners. Notches **67**, **67** accommodate very short radial lugs **69** provided at the opposite forward corner ends of larger pin **60**. As will be observed, particularly from FIGURES 4, 9 and 10 lugs **69** are substantially smaller than the receiving notches **67** in the tooth flanges or side walls. Accordingly, in the assembled condition of the parts, lugs **69** do not contact the tooth or interfere with its position on the shank. The distance between the locking lugs **69**, **69** is slightly greater than the width of shank **25** with the result that these lugs seat over the opposite rim edges of bore **65** in the manner best shown in FIGURE 8. The intervening side wall portions of member **61** conform generally to the elliptical shape of bore **65** and seat firmly against these surfaces in the fully assembled position of the retainer pins as is best illustrated in FIGURE 9.

The bowed condition of locking pin **61** is best shown in FIGURE 8 from which it will be observed that the flat surface **63** is provided transversely of its mid-portion with a rounded rib **72** complemental to a channel **73** formed in flat surface **62** of pin **60**. In the fully assembled position of the pins rib **72** is seated in channel **73** and held under high-pressure contact therewith by reason of the highly stressed or tensioned condition of pin **61**.

Rounded rib or fulcrum **72** and its cooperating channel **73**, which preferably has a larger radius of curvature, not only serve to provide increased assurance that the pins will remain fully and properly assembled, but serve important aditional functions. For example, pin **61** acts to distribute the powerful elasticity forces stored therein by the assembly operation in a fully equitable manner to both side walls of the tooth and in predetermined direction irrespective of wide variations in manufacturing tolerances of the cast tooth and of the two retainer pins. It is of course self-evident that pin **61** is free to pivot about its fulcrum axis as necessary to take care of tolerance variations in the radial height of bosses **68**, **68** and equivalent variations of other surfaces on the opposite lateral halves of the assembly. Equally important is the fact that pin **61** is also free to shift to a limited extent axially of fulcrum **72**, that is transversely of the flat surface of pin **60**. This important capability provides compensation for variations in the radial height of the end corners of bosses **68** and thereby enables pin **61** to shift sidewise in an automatic self-centering manner to a position wherein the load forces are delivered equitably to the tooth and in a direction normal or substantially normal to the flat surfaces on the two pin members.

Another feature of the very powerful resilient locking pin **61** is the fact that its foremost end is rounded and tapered as indicated at **75** whereas its opposite end **76** is relatively blunt and provides a striking surface for a sledge hammer used in forcing this pin into its assembled position. The tapered end, being rounded on its upper side and somewhat thinner on its flat side, is easily started into the wider opening provided at the left-hand side of the assembly as viewed in FIGURE 8. Owing to the slightly misaligned condition of openings **65** and **66**, additional room is available to facilitate assembly of the pins up to the time the tapered end of pin **61** approaches entry into the second one of openings **66**. At this time its rounder outer surface contacts boss **68** whereupon the pin is forced to straighten toward a straight line condition toward flat surface **62** of pin **60**. When it is finally driven until its blunt end is flush with the surface of left-hand tooth flange **37**, it is in highly stressed condition, locking rib **72** is seated in channel **73** and the exterior surfaces of the pin ends are in high pressure frictional contact with bosses **68**, **68**.

Under these conditions the massive pin **60** has substantially all of its exterior surface in firm seating contact with the lower forward surfaces of shank bore **65** and out of contact at all points with the tooth openings **66**. The reverse conditions are true as respects the highly stressed resilient pin **61** which is nowhere in contact with the shank while its opposite ends are in high pressure contact with tooth side wall bosses **68**, **68** in a manner urging the latter upwardly and rearwardly at an angle of approximately 45 degrees to the horizontal as viewed in FIGURES 1 and 4. Accordingly, the beveled surface **40** across the upper end of the tooth main body is pressed against surface **41** of the shank. And in particular, the rear surfaces of the tooth main body are held firmly seated against pads **42**, **42** of the shank seating surface. In this connection it is to be noted that the portion of tooth seat **26** between pads **42** is preferably relieved and out of contact with the tooth at all times.

ASSEMBLY AND OPERATION

The assembly of the tooth is accomplished by placing it astride the forward face of shank **25** and holding it in this position in any suitable manner while pin **60** is inserted into bore **65** by holding the same in the position generally indicated in FIGURE 10. Once the pin is properly centered lengthwise of the bore it can be lowered until its forward and lower side walls seat firmly against corresponding surfaces of bore **65** with its lugs **69** seated loosely in notches **67** of the tooth side walls. The parts will then be in the position indicated in FIGURE 9. Thereafter, the tapered forward end **75** of locking pin **61** is inserted from the left-hand side of the tooth as viewed in FIGURE 8. This pin fits loosely in the opening until its forward end engages the tooth side wall on the far or right-hand side of the assembly. Thereafter it must be forced home by striking blunt end **76** with strong blows using a heavy hammer or sledge. This straightens and tensions pin **61** toward flat surface **62** of pin **60**, the deflection being slightly greater just prior to full seating of locking rib **72** in groove **73**. In its final assembly position, its opposite ends, like those of pin **60**, will be substantially flush with the outer side walls of tooth flanges **37**.

Under these assembled conditions pin **61** will be highly stressed and tooth **35** will be held powerfully and resiliently seated against pads **42** and with its beveled surface **40** firmly seated against surface **41** of the shank notch.

It will also be observed from FIGURE 1 in particular that the side flanges of the protective boot **30** are notched at **77** to conform generally with the shape of the upper portion of the tooth. Accordingly, the retainer pins **60**, **61** assume a principal portion of the load in holding boot **30** against removal while the ripper is being backed through ripped material. Accordingly, the cap screws **31** need not take a principal portion of this load, and relatively small size cap screws serve the purpose of supporting the boot while tooth **35** is detached. During normal forward movement of the ripper through material undergoing ripping, the boot seats against the forward edge of the shank and imposes no particular load on either cap screws **31** or the tooth retaining pin **60**, **61**.

Disassembly of tooth **35** is accomplished by placing a proper sized punch against tapered end 75 of pin 61, and striking it with strong blows to force it to the left (FIGURE 8). Once the pin has been removed larger pin 60 may be withdrawn in the reverse manner of its assembly operation, it being understood that the tooth is suitably locked or otherwise supported against its seat on the shank while the pin is being removed.

To place the ripper in operation, the operator of vehicle 10 operates hydraulic control valves, not shown, to release liquid from the lower end of cylinder 20 and admit liquid to the upper end. The valves are left in these positions as the vehicle moves forward and toe end 39 of the tooth begins penetrating the formation aided, if necessary, by pressure applied by cylinder 20. The weight of the ripper frame, aided very materially by the action of inclined surfaces 46, 49, and 50 as well as by the camming action thereof, continues to force the ripper tooth downwardly into the terrain. As the tooth penetrates, the weight of the burden overlying the tooth becomes increasingly effective in forcing the tooth downwardly even in solid rock. This automatic self-penetrating action of the ripper assembly is very materially aided by the aforedescribed action of the inclined surfaces and of the sharp edges along the perimeters of these faces in causing shearing and cleavage of the rock well in advance of its tip.

As soon as the driver senses that the ripper has penetrated to a proper high-efficiency operating depth, he operates the hydraulic fluid controls to cut off flow to the opposite ends of the cylinders thereby locking the parallelogram linkage rigidly against movement in either direction but principally against further extension of cylinders 20. While the ripper and its parallelogram linkage are so locked it will be apparent that major portions of the load forces acting on the tooth are channeled back through links 13, 14 and the locking cylinders 20 and communicated to the tractor assembly to increase the tractive effort of treads 11. In other words, the greater the load on tooth 35 the greater is the effective weight of the tractor, and the greater is the tractive effort applied by treads 11 to the terrain surface.

The terrain is progressively broken into major portions over a wide belt in the direction of travel, this width being dependent largely on the hardness of the formation since the shearing forces spread more widely in brittle than in softer material.

The wear on tooth 35 is appreciably less than in other teeth operating in the same terrain and over the same distance. Furthermore, this wear is found to take place generally evenly throughout surfaces 46, 49, and 50 with the result that these surfaces tend to maintain their same shape and relationship over prolonged periods of usage and as the tooth wears back toward the lower corner of shank 25. Relatively minor wear occurs along the lower edges of the side flanges and over the arcuate portion of the main body of the tooth rearwardly of camming surfaces 49, 50. It is further pointed out that the major load force acting on the tooth is assumed by the transverse forward end 46 and transmitted lengthwise throughout the length of the tooth body and as a compressive force and is delivered upwardly into the shank across the interface between surfaces 40, 41. These load forces neither tend to increase or decrease the load or the tension stresses in the locking pin assembly and they continue to function with full efficiency to hold the tooth firmly seated against pads 42 and surface 41 regardless of whether the tooth is under load or free of load.

Owing to the efficient shearing action characterizing the invention tooth in operation, the principal downward force on the tooth tip is the weight of the overlying rock. These forces are relatively small compared to those acting against the transverse tip end of the tooth and, as explained, these are transmitted upwardly placing the main body of the tooth under high compression rather than under bending stress. It is for these reasons that the present tooth is designed to project forwardly of the shank by a far greater distance than heretofore. Likewise, it is for this reason that the service life of the tooth is greatly prolonged. Furthermore, as wear occurs it will be appreciated from FIGURES 1 and 4 that the clearance provided between the terrain and the underside of the tooth and of its flanges remains the same. In this connection it will be observed that the lowermost edge of web 53 of the tooth flange and of shank surface 28 both have a clearance angle of approximately five degrees with respect to the horizontal.

While the particular ripper apparatus and method of using same herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiment of the invention and that no limitations are intended to the details of construction or design herein shown other than as defined in the appended claims.

I claim:

1. In combination, a rigid mounting shank for a tooth useful in digging and ripping hard terrain, an opening of uniform cross-section extending transversely through said shank near the lower end edge thereof, said shank having a forwardly facing transverse edge notched across its upper end and shaped to seat the upper curvate end portion of a tooth, a one-piece steel tooth having an elongated curvate main body terminating in a bluntly pointed forwardly projecting ripping end and an upper end shaped complemental to and seated in said shank notch, said main body portion including integral side flanges lying in parallel planes along either lateral edge of said main body and spaced to embrace the opposite sides of said shank, aligned openings through said side flanges in general registry with said opening through the shank but offset slightly forwardly from accurate registry with said opening, and retainer means releasably locking said tooth to said shank including a pair of independent and separate pin members of substantially different size and cross-sectional areas, the larger of said pin members being nonbending straight and shaped to seat against the juxtaposed surface along one side of said shank opening and having a pair of radially disposed lugs at its ends spaced apart a distance slightly greater than the length of the opening through said shank and adapted to engage the rim edges of said shank opening, and the second and smaller of said pin members being longitudinally bowed and of highly resilient material with its midportion bearing against the juxtaposed midportion of said first pin member and the opposite sides of its end portions bearing against the edges of the openings through the tooth side flanges and acting to urge said tooth into fully seated position against the forward edge of said shank, and said second pin member being adapted to be forcibly driven endwise into assembled position only after said first pin member has been installed and properly seated in said shank opening.

2. The combination defined in claim 1 characterized in the provision of a one-piece channel-shaped protective boot for forwardly facing edge and sides of said shank in the area thereof overlying the upper end of said tooth, said boot extending along the major length of said shank and having the lower end edges of its sides shaped complementally to and nested over the upper end of said tooth, and pin means extending through said boot and into said shank and useful for supporting said boot on said shank while said tooth is being assembled and disassembled relative to the shank.

3. The combination defined in claim 1 characterized in that the length of said tooth projecting beyond the foremost end of said shank is in excess of one-third of the length of the main body portion of said tooth and having an average thickness in a vertical plane approximating the thickness of the remainder of said main body.

4. The combination defined in claim 1 characterized

in that said side flanges project slightly below the lower end of said shank and serve as glide surfaces effective to support said shank generally out of contact with hard terrain undergoing working.

5. The combination defined in claim **1** characterized in that said opening through said shank is generally elliptical in cross-section with its major axis substantially vertical and wherein said first pin member occupies the lower forward portion of said opening and wherein said second pin member occupies the upper rearward portion of said opening with its major tooth-retaining forces acting generally in a plane inclined upwardly and rearwardly along at an angle in the vicinity of 45 degrees to the vertical.

6. The combination defined in claim **5** characterized in that in the assembled position of the defined components said first pin member is locked against endwise movement by contact of said lug with the sides of said shank, and said first and second pin members being held against relative endwise movement by interlocking boss and seating means therefor extending crosswise of said pin members at their mid-portions.

7. A ripper tooth adapted to be locked in position on the forwardly-facing arcuately-contoured recessed lower forwardly directed transverse face of a supporting shank, said tooth having a wide long curvate main body of generally uniform thickness and shaped to seat against said arcuately-contoured recessed face of said shank with its upper end bearing against the juxtaposed upper edge of said recess and its lower end supported as a cantilever forwardly of said shank, said main body having a pair of flat generally parallel side flanges integral with the opposite lateral edges of said main body along the upper portion thereof and essentially unattached to said main body along the other edges of said flanges, and said flanges having approximately the same thickness as said main body whereby said tooth can be heat-treated without risk of producing locked-in stresses arising from unequal cooling of different portions thereof during the quenching phase of heat-treating, and aligned openings through said side flanges for use in seating retainer pin means to hold said tooth assembled against the lower forward corner of a shank.

8. A ripper tooth as defined in claim **7** characterized in that the forward end of said tooth is generally straight and normal to the length of the tooth, and in that the opposite lateral faces are generally planar and converge upwardly along angles acute to a longitudinal vertical plane through said tooth and merge with the opposite ends of said straight forward end.

9. A tooth as defined in claim **7** characterized in that said aligned openings through said side flanges are non-circular and generally elliptical in shape with the major axis thereof extending generally vertically in the normal operating position of said tooth, and said openings including a notch and a boss disposed generally diametrically opposite one another in a plane inclined upwardly and rearwardly at an acute angle to the vertical.

10. The combination defined in claim **7** characterized in that the main body and side flanges of said tooth are of generally the same thickness whereby the heat treatment of said tooth does not create areas of unequal stress and strains caused by unequal cooling of said tooth while undergoing heat treatment.

11. The combination defined in claim **7** characterized in that the complementally-shaped interfit renders said retainer pin means effective in combination with said pin means to hold said boot in assembled position on said shank.

12. A ripper tooth as defined in claim **7** characterized in that the forward upwardly directed face of said tooth adjacent the lower end thereof has a ridge extending centrally of its length and tapering downwardly to either lateral edge of said tip.

13. A ripper tooth as defined in claim **7** characterized in that the said straight forward end of the tooth merges with a beveled surface sloping upwardly and rearwardly toward the ridge of said pitched surface.

14. A tooth as defined in claim **7** characterized in that the upper transverse edge of said tooth is beveled upwardly and rearwardly and designed to fit within a complementally-shaped transverse notch across the forward edge of a mounting shank for said tooth.

15. A tooth as defined within claim **7** characterized in that said side flanges extend downwardly along the opposite sides of said main body to reinforce and support the tip end of said tooth and have lower edges adapted to serve as glide shoes for said tooth effective to elevate the tooth while being moved rearward out of a ripping operation.

16. A retainer pin assembly for use in locking a digging member to a supporting shank of the type having an opening therethrough of generally uniform cross-section, said assembly comprising a pair of elongated independent pins of widely differing cross-sectional areas each having a generally flat surface extending lengthwise thereof, the larger pin having a short lug projecting radially from its ends and away from that pin's flat surface, the smaller pin being bowed lengthwise thereof in a direction away from the flat surface of the larger pin and adapted to have its flat midportion bear against the flat midportion of said larger pin, and said smaller pin being highly resilient and adapted to have its exterior end surfaces under high loading pressure when said assembly is forcibly assembled in generally aligned openings of cooperating size formed in a digging member and in a supporting shank therefor.

17. A retainer pin assembly as defined in claim **16** characterized in that said assembly is shaped to occupy aligned openings through a digging tooth and a mounting shank therefor which openings are generally of elliptical shaped and wherein the flat faces of said two pins lie generally at an acute angle to the major axis of said elliptical openings, and one of said pins being free to shift laterally of the other longitudinally of the fulcrum axis between the two pins to assure equitable distribution of forces when the pins are assembled in an operating environment.

18. The combination defined in claim **16** characterized in that the forwardly projecting one-half end portion of said tooth lies generally in a plane below the lower end of said shank.

19. The combination defined in claim **16** characterized in that each of said pins have their respective generally flat surfaces tapering in opposite directions lengthwise of said pins and being adapted for assembly in a supporting shank with their respective smaller ends positioned remotely from one another.

20. A retainer pin assembly as defined in claim **16** characterized in that one set of remotely positioned ends of said pins is thicker than the other set of ends and in that said smaller pin is tapered at one end to facilitate the assembly thereof.

21. A retainer pin assembly as defined in claim **16** characterized in that said pins have a complementally shaped hump and recess crosswise of the midportions of their flat faces cooperating to lock said pins in their normal assembled position and cooperating to permit said pins to pivot relative to one another to compensate for irregularities and variations in manufacturing tolerances.

22. A ripper tooth having a long arcuate main body having a pair of generally parallel side mounting flanges integral with its opposite lateral edges near one end of said body, the opposite tip end of said main body having a ridge extending lengthwise of the top side thereof and including downwardly and laterally diverging surfaces extending across the major width of said main body and merging along the remote edges thereof with acutely inclined planar surfaces forming the opposite lateral faces of the tip end of said tooth, and the transverse tip end of said main body having a planar surface sloping upwardly and rearwardly toward the opposite upper end of said main body.

23. A ripper tooth as defined in claim 22 characterized in that the upper transverse end of said main body projects upwardly in a generally vertical direction when said tooth is supported in its normal ripping position, and said upper end being beveled upwardly and rearwardly away from said tip end and adapted to seat snugly with the seating notch of a supporting shank for said tooth.

24. A ripper tooth as defined in claim 22 characterized in that the top surface of said main body rearward of said ridge and of the sloping surfaces immediately to either side thereof are relieved to form an upwardly and forwardly facing curvate surface serving as a moldboard for ripped material flowing rearwardly along the top surface of said tooth.

25. A ripper tooth as defined in claim 24 characterized in that the acutely and upwardly tapering opposite sides of the tip end of said tooth converge toward one another lengthwise of said main body and toward the front end thereof and are effective in parting the material being ripped and in forcing the tip end of said tooth downwardly as the tooth is advanced into terrain undergoing ripping.

26. In combination, a tractor having a main frame supported on a pair of power-driven track layers arranged along the opposite sides thereof, upright bracket means secured to, projecting upwardly from and forming part of the mid-section of said main frame and located adjacent either lateral side of said tractor, a ripper frame extending across the rear end of said tractor, parallelogram linkage means along either side of said track layers and having their forward ends pivotally connected to vertically spaced points in the mid-section of the tractor frame and to said upright bracket means and their rear ends pivotally connected to said ripper frame, a pair of hydraulic cylinder means arranged to transfer load forces acting on said parallelogram linkage means into the mid-section of said tractor frame to increase the traction of said track layers with the underlying ground, said hydraulic cylinder means having their upper ends pivotally connected to the upper end of said upright bracket means and their lower ends to said parallelogram linkage means forwardly of the rear ends of said track layers, said ripper frame having a ripper tooth shank projecting downwardly therefrom with a ripper tooth detachably connected to the lower forward corner thereof, said tooth having a downwardly and forwardly sloping tip end extending downwardly and forwardly beyond the lower end of said shank and effective as said tractor moves forwardly to penetrate deeper into the terrain automatically as the tooth breaks the overlying terrain upwardly, and the penetrating capabilities of said tooth being effective through said parallelogram linkage means, said bracket means and said hydraulic cylinder means to force the track-laying part of said tractor into firmer and more powerful traction with the underlying surface of the terrain.

27. In combination, a generally vertically disposed ripper shank having a slightly curved lower forward edge and a relatively wide parallel face lying normal to said curved forward edge, the lower end of said shank lying at an acute angle to the horizontal and tapering upwardly and rearwardly from its foremost corner, a ripper tooth having a long arcuate main body provided along its opposite upper sides with integral mounting flanges adapted to fit loosely over the lower forward corner of said shank and a tip end projecting downwardly and forwardly of said lower shank corner, the back surface of said tooth being curved generally similarly to the juxtaposed surface of said shank, and one of said surfaces having accurately finished seating pads across its opposite ends and spaced outwardly from the intervening portions of that surface whereby the load forces applied to said ripper tooth when engaged in a ripping operation are transmitted to said shank essentially through said seating pads.

28. The combination defined in claim 27 characterized in the provision of an opening through the lower end of said shank in slightly offset alignment with a pair of openings through the side flanges of said tooth, a pair of retainer pins assembled in said openings cooperating to lock said tooth assembled to said shank, one of said pins being bowed lengthwise thereof with its opposite ends bearing against the edges of the openings in said tooth side walls in a direction to hold one of said curved surfaces firmly seated on the accurately finished seating pads of the other arcuate surface and the upper end of said main body pressed into the V-notch of said shank.

29. The combination defined in claim 27 characterized in the provision of a V-shaped notch crosswise of said shank at the upper end of said arcuate surface, and the upper end of the main body of said tooth being shaped and positioned to seat in said notch when mounted on said shank.

30. That method of ripping hard terrain and utilizing the weight of freshly ripped material to increase the effective traction forces of a tractor hauling a ripper which method comprises, utilizing parallelogram linkage means to couple the forward end of terrain ripper means to the mid-length of the frame of a track laying tractor having a frame, attaching a ripper tooth to the lower forward end of a ripper shank forming part of said ripper means, providing an adjustable rigid draft-transmitting connection between the ripper means and the mid-length of the tractor frame, utilizing said adjustable draft connection and said parallelogram linkage means to hold said ripper tooth at a desired penetration level in terrain being ripped and to transfer onto the mid-length of the tractor frame a major portion of the weight of broken terrain overlying said ripper tooth as the tractor is propelled forwardly, and utilizing the forces and weight of broken terrain acting on the ripper tooth as the tractor is propelled to increase the tractive effectiveness of the tractor.

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