(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 096 585**
**A1**

# (12) EUROPEAN PATENT APPLICATION

(21) Application number: 83303290.7

(22) Date of filing: 07.06.83

(51) Int. Cl.[3]: E 01 C 21/00
E 01 C 23/06, E 01 C 23/08

(30) Priority: 08.06.82 US 386437

(43) Date of publication of application:
21.12.83 Bulletin 83/51

(84) Designated Contracting States:
DE FR GB

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## (54) An earth working machine.

(57) An earth working machine for removing the surface layer of a paved surface or soil includes a rotor assembly having a drum (39), a plurality of bit holders (100) secured to an outer periphery of the drum and a plurality of cutter bits (160) one being positioned in each of the holders. Drive means are provided for rotating the drum, and the drum is massive enough and rotates at a high enough velocity to have a kinetic energy greater than 117 J/cm of drum width whereby the surface layer of the ground is sufficiently removed.

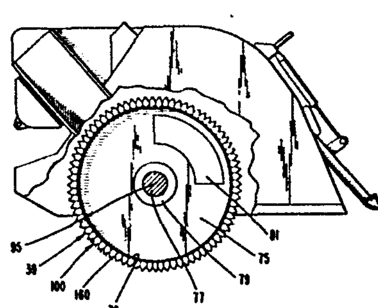


FIG. 2

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# An Earth Working Machine

The invention relates to an earth working machine having a cutter drum assembly useful in working an earth or road surface.

Earth working machines such as self-propelled soil stabilizer machines or roadway resurfacing machines are known. Both the soil stabilizer and the roadway resurfacer employ a horizontal rotor or drum for comminuting and/or mixing soil and other material over which the machine passes. The rotor or drum is provided with a plurality of cutter bits or teeth which are outwardly oriented on the outer periphery of the drum in a form that attempts to provide uniform pulverization or mixing of the ground surface. Such a drum will hereafter be termed a cutter drum.

Such earth working machines may be used to dig up and comminute old asphalt or concrete paving which may then be re-applied to the ground to form a suitable foundation for subsequent operations. Comminution of the old surface is necessary to smooth out the surface of the roadway as well as to avoid buildup of the paved roadway to the extent that it overruns the original curbing, gutters or manhole skirts. Previously this was done in a "hot planing" operation in which heaters in front of the earth working machine heated the road surface to reduce the force required of the cutter drum. Because the roadway serves as a heat sink during hot planing, it was determined that hot planing could not be performed on roadways which were quite cold during winter. More recently, "cold planing" has become the preferred mode of operation because, although it requires more cutting power, it does not need a heater and it can be done during any season of the year.

Further, the earth working machines may be used as soil stabilizers to blend or mix the soil with suitable additives, such as lime or cement. This produces a hardened or "stabilized" soil which can serve as a base for an asphalt or concrete layer.

A road planing apparatus having a plurality of cutter teeth secured on two oppositely directed helical flights is known to the prior art. A number of laterally extending paddle bars are attached between the flights at spaced intervals about the drum near its center portion. The paddle bars are recessed from the cutting heads and serve as scoops to throw the removed paving material cuttings upwardly generally following the drum in its rotary direction. The paddle bars will generally lift the cuttings of the removed pavement material up and over the planing cutter to be received through a passageway onto a material receiving end of a base conveyor so that the material may be conveyed away from the cutting drum. A planer apparatus of this general type is disclosed in United States Patent No. 4,139,318 issued on 13th February, 1979 to Jacob et al.

A mining machine having cutter teeth arranged in a continuous helical or scroll pattern in which the two outer teeth of each helix are angled out over a respective side face of the cutter drum at a localized portion of its perimeter is also known to the prior art. A device of this general type is disclosed in United States Patent No. 4,310,199 issued on 12th January, 1982 to Freed et al.

Since the technology for earth working machines is well developed, the commercial suitability of road planers or soil stabilizers is at present highly dependent on the effectiveness and durability of the cutter drum. The efficency with which the cutter drum digs up the ground surface is at least partially dependent on the kinetic energy of the drum. Because the kinetic energy is dependent on the square of the velocity (K.E. = $^1/_2$ M.V$^2$ where M is the mass of the cutter drum (the weight w divided by the gravitational constant, g) and V is the tip velocity of the cutter teeth on the drum) doubling the tip velocity of the teeth on the drum quadruples their kinetic energy. A cutter drum with a high kinetic energy can comminute harder material than can a lower kinetic energy drum. Moreover, a high kinetic energy cutter drum will power through a hard spot in the ground surface rather than being slowed down significantly, or perhaps being stopped altogether as would happen to lower kinetic energy drums. Thus it has been found advantageous to increase the kinetic energy of the cutter drum to enable it to cut hard spots more easily.

In the cutting drums of the prior art a comparatively high torque motor was used to enable a slow rotating cutting drum to cut through a hard spot in a ground surface. In the present invention, on the other hand, a comparatively high kinetic energy cutter drum is utilized which drum can be powered by a comparatively lower torque motor. Thus, for the same rate of cutting of a ground surface to the same degree of fineness, the high kinetic energy cutter drum of the present invention can use a far less powerful motor than could the cutter drums of the prior art.

Also, the higher the kinetic energy of the drum, and hence the velocity of each cutter tip on the drum, the more easily and finely is the asphalt, concrete or other ground surface pulverized. The rotational speed of a cutter drum may slow down anywhere from 5% to 20% when the drum encounters obstructions and this greatly decreases its kinetic energy. But if the cutter drum initially has a higher kinetic energy, then its kinetic energy after the obstruction will still be relatively high and it will continue to be able to cut the material.

Since the cutter drum is the part most subject to wear, the frequency and cost of its replacement is a major operating concern for the owners and operators of such equipment. Therefore, a suitable cutter must be capable of removing hard materials, such as concrete, as well as the more elastic materials such as asphalt without needing frequent replacement. In this connection it has been found advantageous to reduce the number of teeth on the cutter drum to a design optimum in order to decrease tooth replacement costs as well as to decrease the loss of kinetic energy of the drum when the total number of teeth on the drum bite into the material for each rotation of the drum. Although with less teeth on the drum each of the teeth will wear faster, less teeth will need to be replaced overall, per mile of roadway cut, than in a design employing more teeth. Put another way, the cutter drum of the present invention will cut more surface area per number of teeth replaced than the cutter drums of the prior art.

It was also found advantageous to provide paddles to relieve the cutter drum and guide away the material which has been cut because this has been found to speed up the rate at which the cutting or stabilizing operation can take place. Moreover, it has also been found advantageous to provide cutter teeth angled over the edge of the cutter drum assembly to protect the sides of the cutter drum as well as to reduce the wear rate of the cutter tooth mounting blocks or sockets.

According to the invention there is provided an earth working machine for comminuting the upper layer of an underlying surface, the machine having a chassis supported on the surface, characterised by a rotor assembly including a drum rotatably mounted on the chassis with a plurality of cutter bit assemblies secured to the outer periphery of said drum and extending therefrom, and power means operable to rotate said drum at an angular velocity sufficient to create a kinetic energy for the rotor assembly greater than approximately 117 J/cm of drum width.

Some embodiments of the invention are described below, by way of example, with reference to the accompanying drawings, wherein:-

Figure 1 is a perspective view of an earth working machine on which the cutter drum may be mounted;

Figure 2 is an enlarged side view, partially broken away, of a cutter drum portion of the machine in Figure 1;

Figure 3 is a front elevational view of the cutter drum of Figure 2;

Figure 4 is a planar development of the cylindrical surface of the cutter drum showing the cutter bit and paddle weldment placement;

Figure 5 is an enlarged front elevational view of an end portion of the cutter drum of Figure 3;

Figure 6 is a side view of the cutter drum of Figure 5;

Figure 7 is an enlarged side view in partial cross-section of a cutter bit assembly of the cutter drum of Figure 3 having a rotatable cutter bit;

Figure 8 is a side view in partial cross-section of the cutter bit assembly of Figure 7 with a non-rotatable type of cutter bit;

Figure 9 is a plan view of the cutter bit assembly of Figure 7; and

Figure 10 is an enlarged perspective view of a paddle of the cutter drum of Figure 3.

The present invention may be used with a wide variety of earth working machines such as roadway planers, soil stabilizers or cultivating machines of various different configurations. One such soil stabilizer machine is disclosed in United States Patent No. 3,795,279 issued on 5th May, 1974 to Nelson. By way of illustration, and not intended to limit the present invention, one soil stabilizer machine with which the high kinetic energy cutter drum of the present invention may be used will be described with reference to Figure 1. The machine includes a main frame or chassis 21 having two preferably rubber tired rear traction wheels 23. Two preferably rubber tired steerable front wheels 25 are also provided for the chassis 21. Mounted on the chassis 21 are an internal combustion engine or other suitable power plant 27 and an operator control console 29. An earth working unit 31 is located at the rear of the chassis 21 and is connected thereto by a draw bar 33. The earth working unit 31 may perform the function of comminuting the top surface of a roadway before resurfacing. Alternatively, the earth working unit 31 may be used to mix the top surface of a soil, perhaps with additives, to stabilize the soil.

Included in the stabilizer unit 31 is a horizontally disposed cross tube 35 which is rigidly connected to a pair of spaced apart rearwardly extending lifting arms 37 between which a horizontally disposed rotatable cutter drum 39 (not visible in Figure 1, but see Figure 2) is mounted. The cross tube 35 (Figure 1) is rotatably supported on a support 41 which is secured to the chassis 21. Preferably the cutter drum 39 is rotated clockwise as seen in Figure 1 by hydraulic motors 49 which are rigidly mounted on the lifting arms 37. The cutter drum 39 may be raised or lowered by conventional hydraulic actuators (not illustrated) of a suspension system to the desired cutting depth. If desired, the suspension system may also provide for transverse or lateral adjustment of the cutter drum relative to the chassis 21. A screen 61 may also be provided behind the cutter drum 39, if desired, to sweep larger chunks of material back to the drum for further comminution.

With reference now to Figure 2, the cutter drum 39 includes a large tube 70 fabricated by rolling preferably out of a 250mm thick plate of a hard, wear resistant, material. Steel is one example of such a material. Of course, any other material which is able to take the strain of hard wear, and has a high mass density, would also be suitable. The tube 70 is machined down to approximately 190mm thickness in an operation designed to make the outer surface of the tube concentric. In one preferred embodiment, a diameter of 97.5cm is utilized for the tube 70. The tube 70 in the preferred embodiment has a length of 2m. A cutter circle diameter, that is the diameter of an imaginary circle to the tip of a cutter 160 of each of a plurality of cutter bit assemblies 100, for the above drum is approximately 1.22m.

The tube 70 is provided with a pair of side plates or walls 75 to form the sides of the drum 39. A stub axle 77 is secured to each side plate 75 and extends into a respective roller bearing 79 to rotatably support the cutter drum 39. Preferably, at least a static balance check is run on the cutter drum 39 to ascertain whether it is balanced and one or more balance weights 81 may be added to the side plates 75, after the cutter bit assemblies 100 have been secured to the drum 39, if necessary. The balance weights 81 compensate for weight unbalances of the cutter drum 39 so that it does not vibrate during its rotation.

With reference now to Figure 3, a total of 154 cutter bit assemblies 100, each having one bit or tooth 160, are preferably provided on a 1.22m cutter circle diameter drum 39. The size of the bit assemblies 100 with respect to the drum 39 in Figure 3 is exaggerated somewhat for clarity. Of course, a larger or smaller number of bits or teeth 160 may be provided on the drum 39 as desired or as found to be advantageous in a particular use of the cutter drum. Naturally, if the cutter circle diameter is different or the drum width is different a different number of bits will have to be used. A plurality of paddles 200 is also provided to displace the comminuted pavement or soil away from the cutter bit assemblies 100.

It has been found that the more bits there are on the drum the more even a plane can be cut in the ground surface by the drum. With fewer bits, the drum will have a tendency to only cut grooves in the ground surface and ridges will remain between the grooves. On the other hand, with a larger number of bits there are on the drum, the more slowly the drum turns when driven by the same horsepower motor since the drum is slowed by the impact of each bit with the ground surface. As the drum rotates more slowly, the entire cutting operation is slowed, which is disadvantageous. Thus the ideal balance would be the fewest number of bits necessary to cut a full width on center of the drum in the ground surface but with only one bit cutting at each point along the width of the drum. In this way no uncut ridges are created in the ground surface and also the drum is not excessively slowed.

Ideally, it should only be necessary to make one trip over the ground surface to adequately comminute or stabilize the surface. With many earth working machines, however, more than one trip may be necessary. After the machine's passage the ground surface is tested and a predetermined percentage of the comminuted material has to pass through a predetermined size screen to indicate that adequate comminution has taken place. With the drum of the present invention the comminution of the ground surface can take place with fewer, and faster, trips over the same ground surface.

With reference now to Figure 4, the rotor weldment discloses positions of the paddles 200 and cutter bits 160 around the circumference of the drum 39. As mentioned, in one preferred embodiment 154 bits are provided on the drum 39 although more or less bits may be used as desired or necessitated by circumstances. In this preferred embodiment, no less than one bit 160 and no more than three bits are provided on any five degree section of the drum, as evidenced in Figure 4. The bits are placed in a generally random pattern but so that for one rotation of the drum only one bit will cut along each increment of width along the drum while still cutting evenly into the ground surface. Also, the bits are so placed that the rotational balance of the drum 39 is maintained. Of course, the cutter drum 39 could be designed to have a cutting circle diameter of 1.5m or larger if so desired. Alternatively, the cutting circle diameter can be reduced to approximately 0.75m or less if desired.

The patten of the teeth or cutter bits 160 may vary with the application, the material to be cut or other considerations. Generally, the pattern is subject to three considerations. First, there must be a dynamic balance for the drum 39. Secondly, there should not be any augering of the comminuted material by the cutter bits 160 as this reduces the efficiency of cutting. Thirdly, the number of bits digging at the same time should be limited. The number of bits digging at the same time depends on the depth of cut. With a 2m wide drum and a depth of cut of 36cm, a drum arc of approximately 80° (or 20% of the circumference of the drum) will be in contact with the ground surface. With a drum having 154 bits, approximately 35 bits will be in ground contact. Normally, the depth of cut will be approximately 18cm, and approximately 10% of the bits on the drum will be in contact with the ground surface. In this case, for a 2m wide drum having 154 bits approximately 15 to 20 bits will be in ground contact. Normally, it is desirable to have a pattern in which two or more bits, equidistant from each end of the drum, are engaging the ground surface at all times to balance or distribute the loading on the drum and its bearings.

Preferably, the cutting drum 39 is so dimensioned that the cutting points of all of the cutter bits 160 are disposed equidistantly from a rotational axis 95 (see Figure 2) of the drum. This insures that the cutting points define a uniform line of cutting parallel to the axis of the drum. This uniform line is located at the deepest plane reached in the ground surface by the cutting points as the drum 39 is rotated. The cutting line becomes a cutting plane as the rotating drum 39 is translated forward on the chassis 21.

With the diameter of the rotor or cutter drum 39 being in the range of 1 to 1.5m and its width being 2 to 2.4m and the weight of the cutter drum being anywhere from 1815 to 2720 Kg and cutter teeth tip velocities of 6.33 to 12.7m/s, a kinetic energy of at least 20.3kJ may be obtained. The design speed of a 1.22m diameter drum 39 (that is, diameter from cutting tip to cutting tip) is approximately 150rpm plus or minus 10rpm and the designed torque is approximately 8.15 to 9.5kJ. This translates into a kinetic energy of 117 to 410 J/cm of drum width.

In one preferred embodiment, with a 1.22m tip diameter drum having a weight of 2088Kg and an average speed of drum rotation of 150rpm with a motor having a torque of 7.73kJ, the kinetic energy to torque ratio (KE/T) will be 4.8 to 1. The KE/T ratio may be anywhere from 3 to 1 to 10 to 1 but is ideally 3.5 to 1 to 5.5 to 1. If the ratio is too high it becomes difficult to manage the cutting operation due to the strains put on the cutter bit assembly. Another problem with a high KE/T ratio is that this means a high impact force for the cutter bits against the surface being cut, which, if the KE/T ratio is too high, will have the dislodged material flying fast enough to injure someone or harm the machine itself. On the other hand, if the KE/T ratio is too low then the cutter drum cannot cut through the hard spots encountered.

The cutter drum 39 of the present invention is provided with a high torque which is necessary to deliver a large impact to dislodge or shear tougher material as it is encountered by the cutter bits 160 of the cutter drum. Therefore, the cutter drum or rotor 39 of the present invention has an adequate torque capacity to continuously cut or shear materials from a road bed, for example, and possesses a high enough kinetic energy to dislodge and crush even tougher materials. Such tougher materials are frequently encountered in recycling, planing and soil stabilizing operations. The present cutter drum or rotor 39 therefore possesses a very efficient combination of torque and kinetic energy. This combination of torque and kinetic energy available in the drum 39 means that the cutter bits 160 are provided with high tip velocities and high inertia to velocity changes. Because the cutter drum assembly 39 has a high kinetic energy for pulverizing material, the cutter drum can do rough duty cutting which other cutter drums might find difficult to do, if not impossible.

Due to the high kinetic energy of the rotor or cutter drum 39, it is capable of cutting tougher material than similar comparably powered drums. Since the amount of work done to shear material from a road bed or other ground surface for a fixed rotor width and depth of cut and for a fixed travel distance is a constant, only a minimum amount of energy is expended and hence a smaller motor can be used since a minimum loss of rotor speed occurs.

From classical physics it can be shown that:

$$KE_{INIT} = \tfrac{1}{2}\ I\,\omega_I^2 = \tfrac{1}{2}\ m\,V_{gi}^2$$

where m = mass of the drum or rotor (which is the weight of the rotor divided by the gravitational constant g), $V_{Ti}$ = initial velocity of cutting tooth tip, $\omega$ = angular velocity (in radian per second) $r_g$ = radius of gyration, $r_t$ = tip radius, $V_{gi}$ = initial velocity of gyration, and I = moment of inertia of a mass.

since $I = m\ r_g^2$

for a mass, a radius of gyration and a velocity of gyration chosen to equal a cutter drum assembly.

The work done by the rotor may be calculated as a function of the loss of kinetic energy by the drum:

$$\Delta \; KE = KE_{INIT} - KE_{FINAL}$$

If the masses m of the two drums are the same, and if the radii of gyration as well as the tip radii are the same, and for a fixed percent slowdown from initial velocity for each drum then the ratio of work done may be simplified to:

$$\frac{W}{W_c} = \frac{V_{Ti}^2}{V_{Tic}^2}$$

where W = work done by the drum and where the subscript c is used to indicate the competing drum.

It can be seen that ratio of work done, normalized per unit width of drum, varies as the square of the ratio of tip velocities. Hence if the ratio of tip velocities for the drum of the present invention to the competing drum is a ratio of two to one the ratio of work done is four to one:

$$\frac{W}{W_c} = \frac{(2)^2}{(1)^2} = \frac{4}{1}$$

If the velocities vary by a ratio of four to one, the ratio of work done varies by sixteen to one:

$$\frac{W}{W_c} = \frac{(4)^2}{(1)^2} = \frac{16}{1}$$

With the cutter drum 39 of the present invention less power per cm of cut (that is to say, the power delivered to the drum 39 divided by the width of the drum) can be delivered to the cutter drum as compared to conventional cutter assemblies while yet producing the same efficient cutting action thereby saving energy. Thus the cutter drum of the present invention may have 617 W/cm of cut but can keep pace with another drum having 1088 W/cm of cut and cut equally tough material. Thus a motor smaller than would be capable of adequately powering the comparison drum will still be able to power the drum 39 of the present invention. In the above example, the present invention has a cutter assembly weight of approximately 2090 Kg and a cutter teeth tip velocity of 9.6m/s while the comparison drum has a weight of approximately 1525 Kg and a tip velocity of 5.4m/s.

The drum 39 of the present invention will also provide approximately sixteen times as much impulse force as a drum of equal weight but only rotating one fourth as fast. It can be shown from dynamics that:

$$F_I \times \Delta t = M (V_I - V_F)$$

where $F_I$ = the impulse force and where t = the duration of the impulse.

The ratio of the impulse forces of the drum of the present invention to a competing drum would then be:

$$\frac{F_I}{F_{I_C}} = \frac{M(V_I - V_F)}{M(V_{I_C} - V_{F_C})} \times \frac{\Delta t_c}{\Delta t}$$

where the subscript c represents in each instance the comparison figures for the comparison drum. If the masses are the same and for a fixed percent slowdown in rotor speed of each rotor, the equation may be simplified to:

$$\frac{F_I}{F_{I_C}} = \frac{V_I}{V_{I_C}} \times \frac{\Delta t_c}{\Delta t}$$

With a ratio of four to one in the velocities of the drum of the present invention to the competing drum, the time duration of the impulses should also vary by a ratio of one to four. That is, the competing drum, since it is only moving at a fourth of the speed of the drum of the present invention, will have a time duration of impulse approximately four times as long. Thus the drum 39 of the present invention will have an impulse force approximately sixteen times the size of the impulse force of the competing drum. When the bits 160 contact the ground surface with a high impulse force, the surface is much more easily comminuted than if it were contacted by the same bit having a lower impulse force.

With reference now to Figure 5, twenty-four of the total number of cutting bits 160 are used on the ends of the drum 39 to reduce the wear on the sides of the drum. These bits 160 also increase the life expectancy of the cutter bit assemblies 100. Twelve bits 160 are located on each end of the drum with the bits 160 being preferably located 30° apart from each other around the circumference of the drum 39. Of course, the spacing of the angled bits 160 may be varied as is desired.

The edge structure of the cutter drum 39, has an upper cutter bit assembly 100 including a cubical bit block pad 110. For the first cutter bit assembly 100, the bit block pad 110 has a top surface (upon which one bit block or socket 120 is secured) parallel to the bottom mounting surface of the block (as in cutter 100). Below the upper cutter 100 is a second cutter 100' which has an angled bit block pad 112. The angled bit block pad 112 is at approximately 20° to 25° angle (as in cutter 100'). Below the second cutter 100' is a third cutter 100" which has a more steeply angled bit block pad 114. The final bit block pad 114 of the group is at a steeper angle of approximately 40° to 45° (as in cutter 100"). The second cutter bit 160' protects the first cutter bit 160. Similarly, the third cutter bit 160" protects the second cutter bit 160'. Of course, any other suitable angle may also be used as desired. Generally, the second cutter bit 100' should only be angled outwardly half as far as the third cutter bit 100" to protect the third cutter bit. If the bits 160 are angled too much, however, they break off during use. On the other hand, if the bits are not angled far enough, the edge bit blocks 120 as well as the edge bit block pads 110, 112, 114 are worn away during the cutting process.

The third cutter bit 160'' protrudes beyond the surface of a bit pad or socket 120 upon which it is seated and the cutter drum or tube edge itself to relieve the region between the rotating surface and the uncut surface. This improves the life expectancy of the sockets from material washout. The feature of the cutter bits oriented angularly in a progressive fashion of the present invention has been found to be particularly useful in reducing resistance to cutting when making cuts while negotiating turns with the machine. Without the angled cutter bits of the present invention, a conventional cutter drum has difficulty in negotiating turns because the edges of the drum bind against the uncut surface.

As mentioned, these three kinds of bit holders are preferably equiangularly positioned around the circumference of the rotor or drum 39 at thirty degree spacing so that four sets of three cutter bits each may be provided at each end of the cutter drum 39. Naturally, any other sequence of bits may be used as desired. Preferably, the bit blocks 120 used the edges of the drum 39 are hard faced to minimize the amount of wear on them. The bit blocks 120 used on the main portion of the drum 39, or main blocks, do not need to be hard faced but may be if that is thought desirable. The present positioning of bits 160 on the edge of the cutter drum 39 appears to offer the optimum arrangement for good production and good bit life.

With reference now to Figure 7, the bit block pads 110 are secured, for example by welding, to the outer periphery of the cutter drum 39. The bit blocks or sockets 120 are then each secured, for example by welds 170, to the pads 110. The type of bit block 120 which is preferably used in the multi-purpose recycling rotor or drum 39 of the present invention can accommodate two kinds of cutter bits 160.

On the one hand, rotating bits 165, provided with a conical carbide tip 180 may be inserted in an opening 140 of each bit block 120. The openings 140 are typically located at a 45° angle to a tangent to the drum 39 periphery at the location of each bit block 120. Hence the center line of the bits 160 are also at a 45° angle. Although the angle could, of course, be other than 45°, that angle has been found to be most advantageous for cutting operations. The rotating bits 165 have a circular body and are thus able to rotate in the bit block 120.

On the other hand (with reference now to Figure 8), a flat bit 167, having a nonrotatably carbide tip 185 may be provided. The flat bit bit 167 is prevented from rotation by the cooperation of a protruding rear extension 168 of the bit 167 with an inner flange or shoulder 150 in the opening 140 of the bit block 120. The rotating bits 165 are useful, preferably, for recycling pavement whereas the flat bit 167 are useful predominately for soil stabilizing operations.

With reference now to Figure 9, it is also preferred that the bit blocks 120 are angled outwardly from a center line C of the drum 39 (see Figure 3) causes a torque imbalance on the sides of each bit thus causing bit rotation without side load on the machine and the bearings. Such outward orientation or angling from the center line of the drum 39 is approximately 0.5° to 2°. In the preferred embodiment, an angle of approximately 1° of outward orientation is used and all the bit blocks 120 on the right of the center line C of the drum 39 (see Figure 3) are angled to the right 1° whereas all the bit blocks to the left of the center line C are angled to the left by 1°.

With reference now to Figure 10, the cutter drum 39 is provided with a plurality of paddles 200 for moving the dirt or pulverized material away from the cutting surface of the drum 39. In one preferred embodiment twenty-four paddles 200, with approximately two paddles being located along the length of the cutter assembly and placed approximately 20° to 30° apart angularly are provided (see the rotor weldment of Figure 4). Of course, more paddles 200 or less may also be found advantageous for some applications. Each paddle 200 is secured immediately in front of a cutter bit block 110, for example by welds 205, to both the bit block as well as to the drum surface. The paddle 200 may be welded to the bit block 110 at an angle in order to decrease the strains on the drum 39 at the weld of the bit block (see Figure 6). Usually, however, the paddles 200 are oriented perpendicularly to the periphery of the drum 39 in order to more easily direct the material away from the drum 39.

These paddles 200 act to relieve the cutter drum 39 and the cutters 160 by flipping the already cut material over the drum 39 to its back side thus providing for a cleaner cutting action at the shearing plane. The paddles also reduce wear due to the loose material around the bit assemblies 100. It has been found that the placement of paddles 200 around the cutter drum 39 in the preferred embodiment increases production speeds on a given soil or surface by as much as 50% to 100%.

In one preferred embodiment, the paddles 200 are approximately 152mm long, 13mm wide and 50mm high. The bit block pads 110 may be cubical and approximately 50mm on a side. The bit blocks 120 may be polygonal and approximately 38mm wide and 50mm high and deep. Of course, any other size for the above components may be used as desired. All three, the bit block pad 110 the bit block 120 and the paddle 200 are preferably made of a hard, abrasion-resistant material such as steel.

Claims:

1. An earth working machine for comminuting the upper layer of an underlying surface, the machine having a chassis supported on the surface, characterised by a rotor assembly including a drum (70) rotatably mounted on the chassis (21) with a plurality of cutter bit assemblies (100) secured to the outer periphery of said drum (70) and extending therefrom, and power means (49) operable to rotate said drum (70) at an angular velocity sufficient to create a kinetic energy for the rotor assembly greater than approximately 117 J/cm of drum width.

2. An earth working machine as claimed in Claim 1, characterised in that the axis or rotation of the drum (70), in use, is generally parallel to the surface of the earth and is generally perpendicular to a path of movement of the earth working machine, the cutter bit assemblies (100) are a plurality of main bit block pads (110) secured to the outer periphery of the drum (70) and extending radially therefrom with an upper surface of each main bit block pad (110) substantially parallel to the periphery of the drum, a plurality of edge bit block pads (112, 114) secured to edge portions of said periphery of said drum and extending radially therefrom, an upper surface of a majority of said edge bit block pads being angled at an acute angle with respect to said periphery, a plurality of bit blocks (120), one secured to said upper surface of each of said main and edge bit block pads, an aperture (140) extending through each bit block, and a pluralitty of bits (160), one positioned in each aperture.

3. An earth working machine as claimed in Claim 2, characterised in that a predetermined number of bit block pads (112, 114) and corresponding cutter bits (160, 160', 160") are distributed on said drum outer periphery such that each bit will cut along a corresponding increment of width of the drum, the predetermined number of bits being sufficient to provide a uniform cutting plane as the drum is moved forward over the ground surface whereby only a minimum loss of rotor speed occurs during the cutting process as the predetermined number of bits contacts the ground surface.

4. An earth working machine as claimed in Claim 3, characterised in that a number of said plurality of main bit block pads (112, 114) is located on each side of the plane bisecting the axis of the drum and are angled away from the plane towards the side faces of said drum.

5. An earth working machine as claimed in Claim 4, characterised in that, the cutter bits (165) are rotatably mounted in the bit blocks (120) and the bits (165) rotate due to a torque imbalance caused by said outward angling of a plurality of main bit block pads.

6. An earth working machine as claimed in Claim 4, characterised in that the cutter bits (167) are fixedly mounted in the bit blocks (120).

7. An earth working machine as claimed in Claim 3, characterised in that said edge bit block pads are equiangularly positioned around said cutter drum, and at least one set of three edge bit block pads is provided, a first edge bit block pad (110) not being angled outwardly, a second edge bit block pad (112) being angled outwardly in the range of 20° to 25° and a third edge bit block pad (114) being angled outwardly in the range of 40° to 45°.

8. An earth working machine as claimed in Claim 7, characterised in that fourth sets of three edge bit block pads each are provided on each edge of said drum, each of said pads being spaced by 30° from an adjacent pad.

9. An earth working machine as claimed in Claim 3, characterised in that two or more bits (160), which are equidistant from each end of the drum, engage the ground surface at any one time to balance the force loading on the drum and its bearings.

10. An earth working machine as claimed in Claim 3, characterised by a plurality of paddle bars (200) secured to the periphery of the drum to displace comminuted material away from the drum.

11. An earth working machine as claimed in Claim 10, characterised in that the paddle bars (200) are provided in pairs located at intervals of 20° to 30° around the periphery of said drum.

12. An earth working machine as claimed in Claim 3, characterised by at least one balance weight (81) secured to a side surface of said drum (39) to compensate for weight unbalances of said drum as it rotates.

13. An earth working machine substantially as herein desribed with reference to the accompanying drawings.

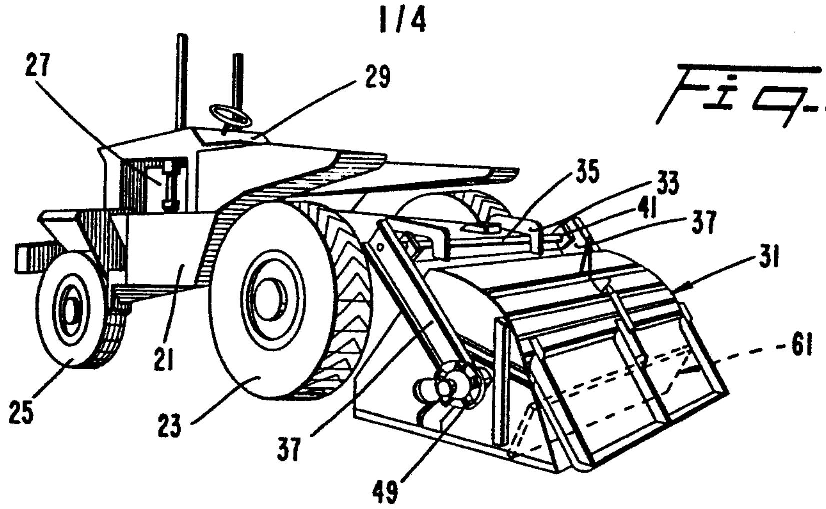



Fig.1

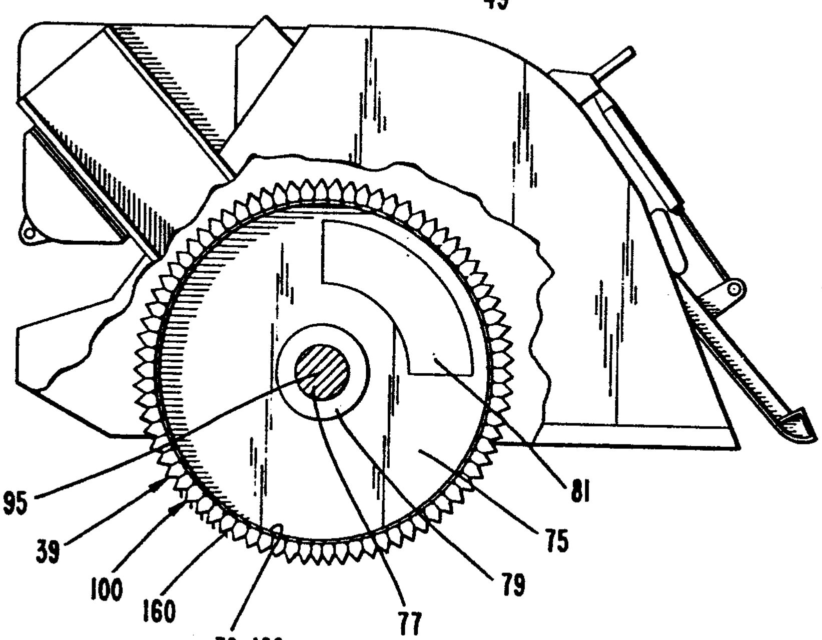



Fig.2

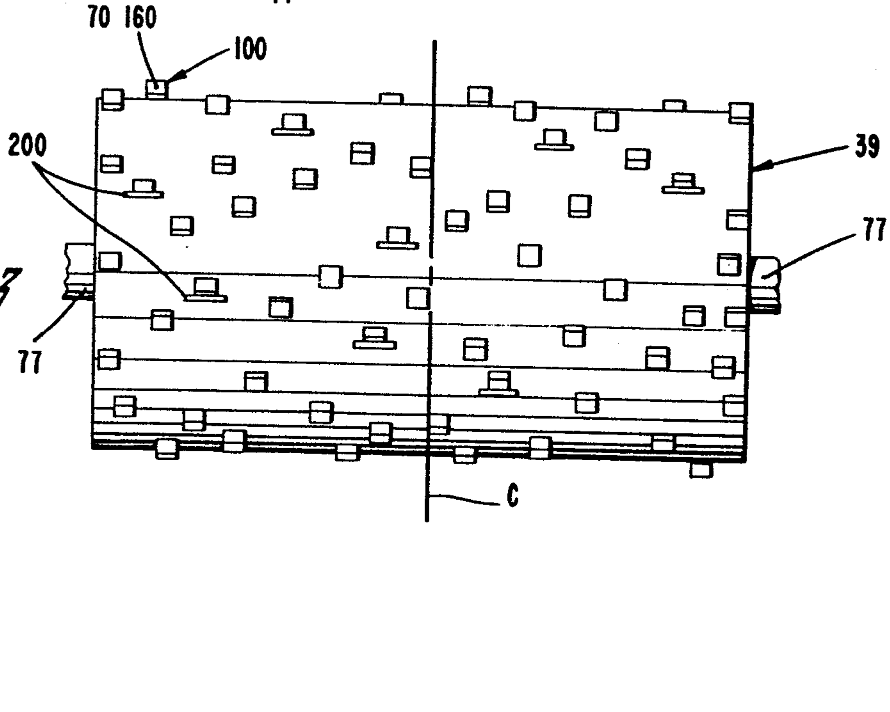
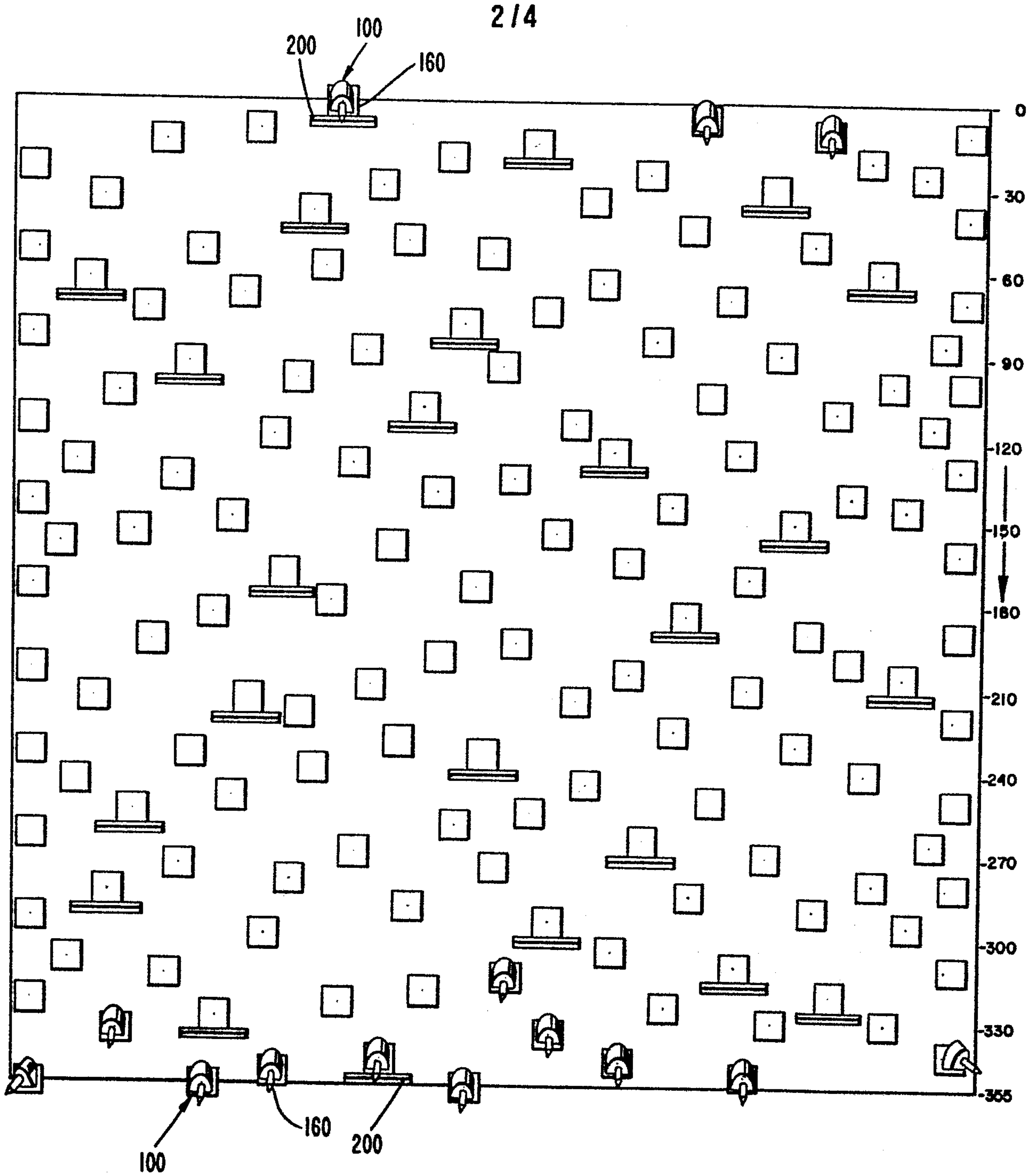



Fig.3



100
200
160
0
30
60
90
120
150
180
210
240
270
300
330
355
100
160
200


Fig. 4

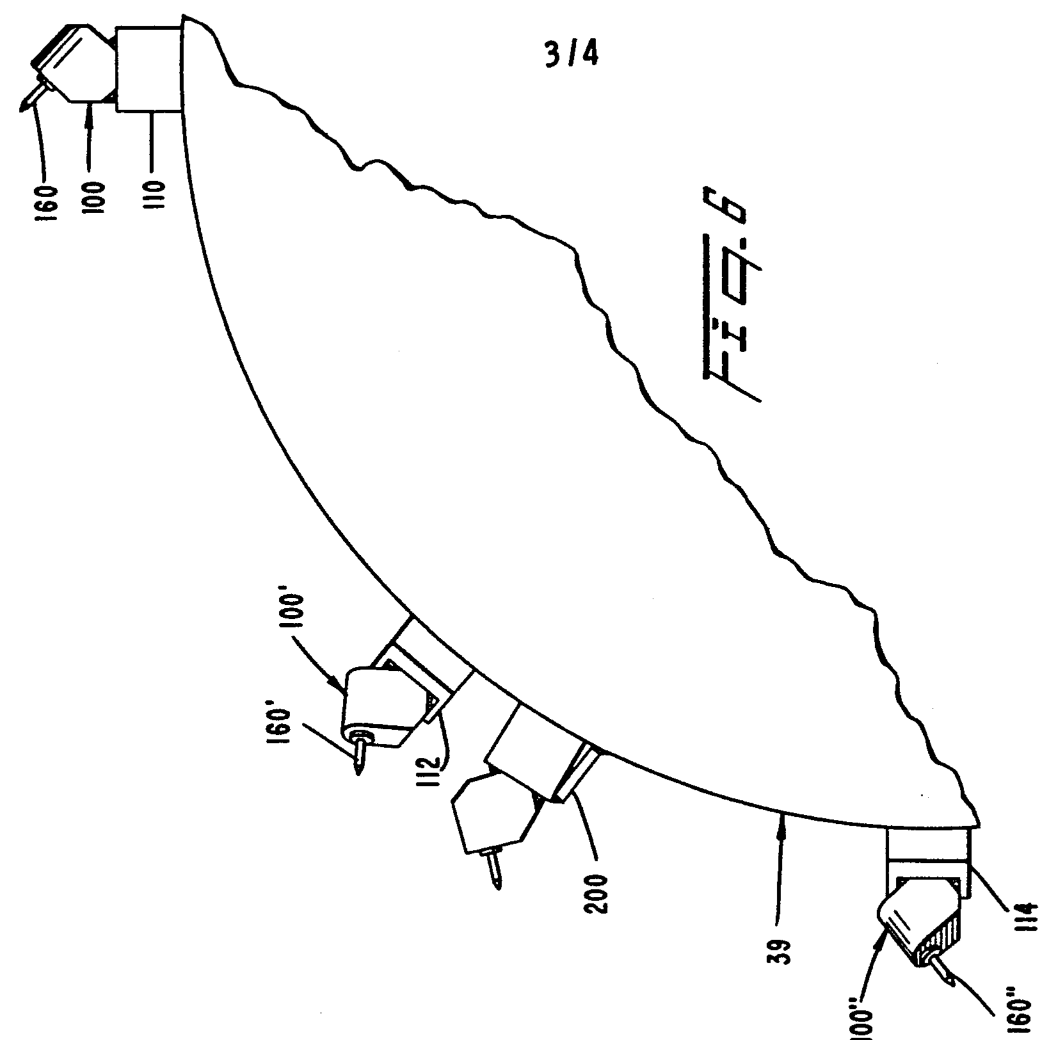

160
100
110
100'
160'
112
200
39
114
100"
160"

FIG. 6

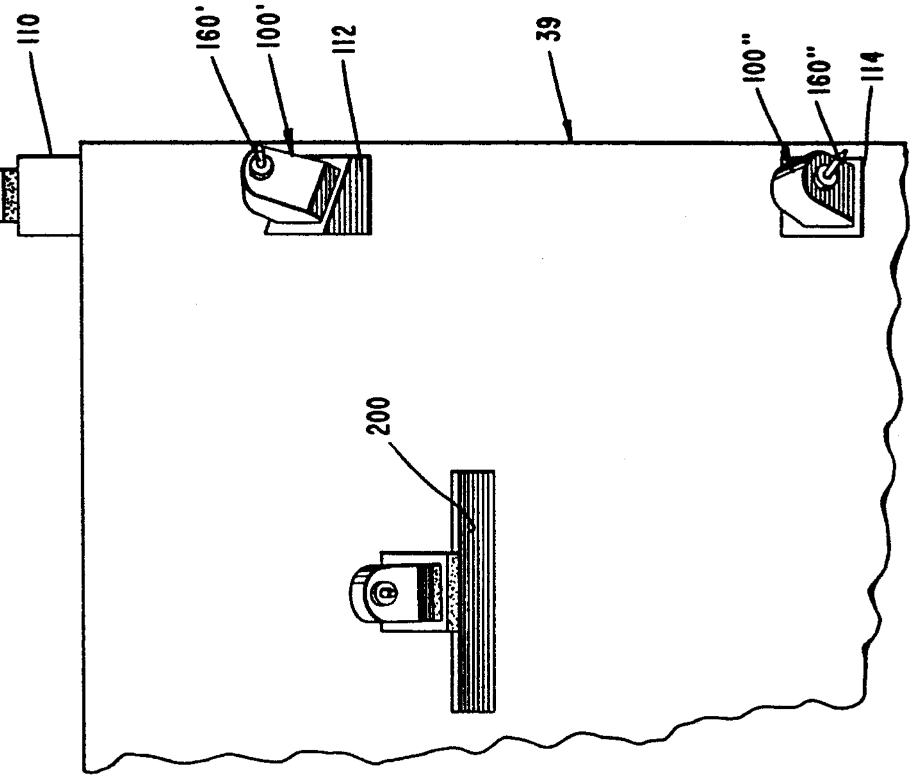

160
100
110
160'
100'
112
39
100"
160"
114
200

FIG. 5

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Fig. 7

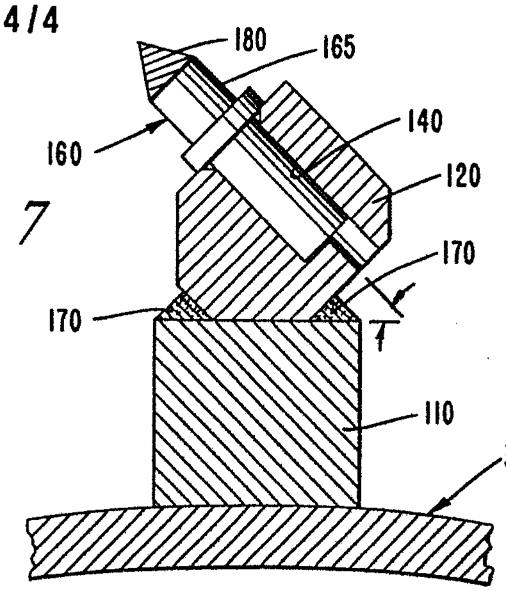



Fig. 8

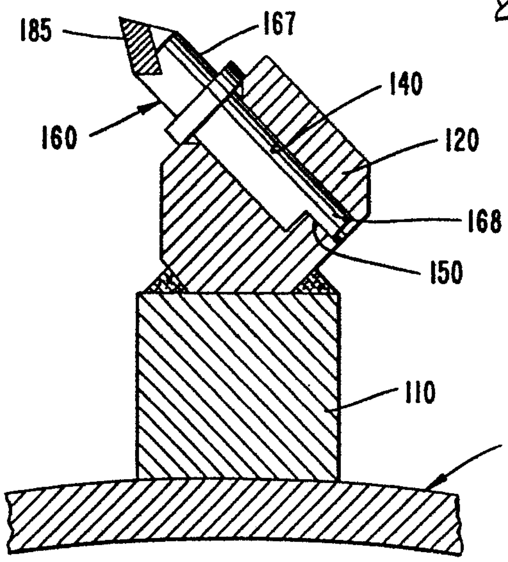



Fig. 9

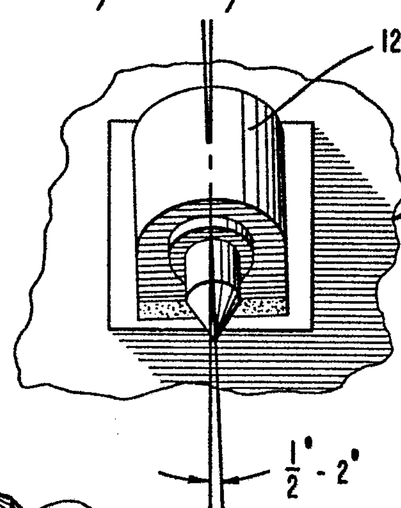
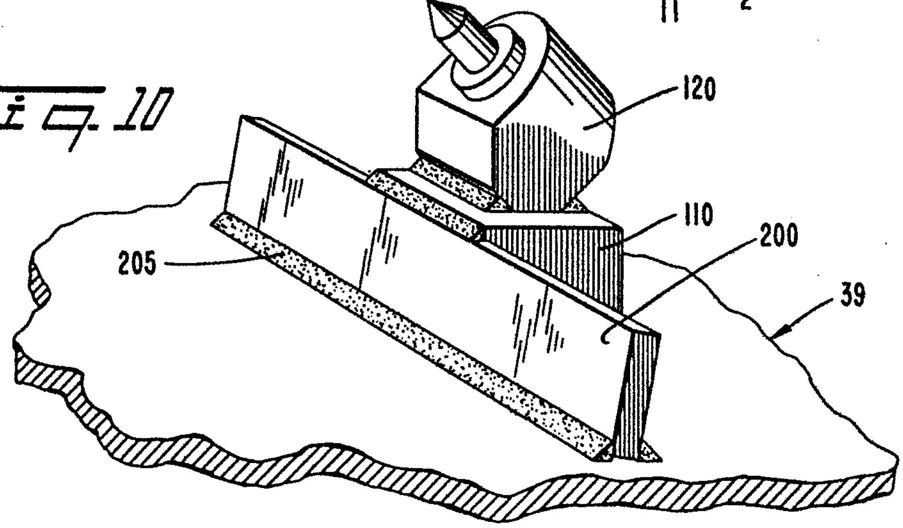



Fig. 10



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# EUROPEAN SEARCH REPORT

0096585

Application number

EP 83 30 3290

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl. 3) |
|---|---|---|---|
| A | AU-B- 60 885 (GREENSIDE MACHINE CO. LTD.) * Page 2 - page 5, paragraph 3; page 7; figures 1, 3 * | 1,2,6 | E 01 C 21/00<br>E 01 C 23/06<br>E 01 C 23/08 |
| D,A | US-A-3 795 279 (NELSON) * Figures 1, 3 * | 1 | |
| A | DE-A-2 517 950 (MARKS & CO.) * Page 5, paragraph 2; figure 2 * | 2,3 | |
| A | US-A-4 302 055 (PERSSON) * Column 2, lines 20-42 * | 2,5 | |
| A | DE-A-2 644 992 (WIRTGEN) * Page 5, last paragraph - page 6, paragraph 1 * | 5 | TECHNICAL FIELDS SEARCHED (Int. Cl. 3) |
| A | GB-A-2 041 289 (KENNAMETAL INC.) * Abstract; figures 1-9 * | 6 | E 01 C 21/00<br>E 01 C 23/00 |
| D,A | US-A-4 139 318 (JAKOB et al.) * Column 9, lines 43-51 * | 10 | |
| D,A | US-A-4 310 199 (FREED et al.) | | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| BERLIN | 17-08-1983 | PAETZEL H-J |

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