Mounting arrangements for roller-type earth cutters, used in continuous boring or tunneling machine, which prevent an excessive loading of a cutter. In one embodiment, spring-type means urge the cutters outwardly from a support and thrust surface, such as a cutterhead, and yields under a predetermined load to allow inward movement of the cutter to prevent overloading thereof. In another embodiment, hydraulic-fluid-pressure-powered plungers, manifolded together from a common source of fluid pressure, urge cutters against the work face, and excessive loading of any one cutter displaces some of its plunger fluid to other cutter plungers whereby the loading is substantially averaged for all cutters.

8 Claims, 10 Drawing Figures
EARTH CUTTER MOUNTING MEANS

This invention pertains to means for mounting cutters, and in particular to mounting means for rotating type earth cutters used on a support surface, such as the cutterhead of a continuous boring machine which, during boring operations, under high thrust load, urges the cutters against the earth face. The mounting is designed to prevent overloads on the cutter arising from, for example, irregularities in the earth face, and thereby increases the cutter life.

Earth cutter mounting means known in this art are rigidly mounted to a cutterhead, so that there is essentially no "give" of the cutter when thrust loads are applied. Accordingly, on a cutterhead with multiple, rigidly mounted cutters, it is possible for a cutter, at some time or other, to become destructively loaded whenever it is subjected to unequal loading, as when it rolls over a loose rock or high point of the earth surface. Of course, when a single cutter encounters any material protruding from the normally planar work surface it must take a thrust loading sufficient to fracture the material, which loading could be the full thrust applied to the cutterhead. This has the effect of relieving the loading on all the other cutters and transferring the loading to the one cutter. This condition will also arise when only some of a plurality of cutters, on a cutterhead, for instance, encounter soft areas in the earth face. This transfers more of the loading to those cutters encountering harder earth. Under these conditions, it is conceivable that but a few, or even one, cutter could momentarily receive the full thrust load of the advancing thrust surface (cutterhead). This type of loading, although intermittent, can severely reduce the life of cutters.

It is an object of this invention, therefore, to teach earth cutter mounting means which overcomes this problem.

It is another object of this invention to teach earth cutter mounting means, comprising means for cutting relatively unyielding materials; means adapted to couple said cutting means to a thrust member; and means adapted to be coupled to said thrust member, and operatively reactive therefrom, for urging said cutting means away from said thrust member.

Another object of this invention is the setting forth of an earth cutter mounting means adaptable to a thrust member, comprising earth cutting means; means coupled to said cutting means adapted for movably mounting said cutting means to said thrust member; said mounting means being cooperative with said earth cutting means to define of said earth cutting means an earth-cutting profile; said mounting means comprising means for effecting a uniform engagement of said earth cutting means and said profile thereof with an earth surface and means operatively reactive in response to an engagement of said earth cutting means with an uneven earth surface, automatically to adjust said profile into a complementary unevenness.

A feature of this invention comprises earth cutter mounting means which allows one or more of roller-type earth cutters to yield when they are excessively loaded. In a plurality of the embodiments presented, resilient means urge the cutters outwardly from a cutterhead, to which the cutters are adaptively mounted, for engagement with the earth face. In another plurality of embodiments, hydraulic-fluid-powered plungers urge the earth cutters toward an earth face and novelly-provisioned hydraulic fluid supply arrangements enable a retraction of any one or more cutter, and extension of two or more cutters, so that the loading of all cutters can be substantially averaged when the cutters are addressing an uneven earth face.

Further objects and features of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying figures in which:

FIG. 1 is a plan or top view of a portion of a cutterhead, such as is used in boring or tunneling machines, with a rotatable earth cutter resiliently mounted thereon, the same being one embodiment of an earth cutter mounting means according to the invention;

FIGS. 2, 3, and 4 depict, respectively, a plan or top view of a portion of a cutterhead with a rotatable earth cutter resiliently mounted thereon, according to another embodiment of the invention; a sectional view taken along section 3—3 of FIG. 2; and a sectional view taken along line 4—4 of FIG. 3;

FIGS. 5 and 6 are plan or top views of portions of cutterheads having pivotally-mounted, rotatable earth cutters, according to further embodiments of the invention;

FIGS. 7 and 8 are still further embodiments of pivotally-mounted, rotatable earth cutters in accordance with the invention, in additional embodiments, shown in plan or top views of cutterhead portions. The embodiments of FIGS. 5 through 8 dispose the earth cutters for movement, relative to the cutterhead, by means comprising pressured-fluid devices;

FIG. 9 schematically depicts a first embodiment of a hydraulic fluid supply and distribution system usable with the embodiments of FIGS. 5 through 8; and

FIG. 10 schematically depicts an alternate embodiment of a hydraulic fluid supply and distribution system also usable with the earth cutter mounting embodiments illustrated in FIGS. 5 through 8.

In the following discussion and description of the several inventive embodiments, same or similar index numerals are used, it should be understood, to signify same or similar components.

As shown in FIG. 1, the earth cutter mounting means 10 according to this embodiment comprises means adapted to be mounted on a thrust member, such as cutterhead 12. In U.S. Pat. No. 3,386,520; issued June 4, 1968; to J.C. Lawrence and W. H. Hamilton; for an "Apparatus for Anchoring the Pilot Member in a Pilot Bore," is shown in a boring machine, of the type with which this invention is useful. As exemplified by the apparatus of the afore-noted patent, a cutterhead, comprising as a thrust member which applies a relatively constant thrust, through the cutters mounted thereon, against the earth face. By way of example, then, thrust member or cutterhead 12, only a portion of which is shown, has a pair of webs 14 and 16 which are bored at 18 and 20 to facilitate the fixing of the mounting means 10 thereto. Ends 22 and 24 of a mounting rod 26 are slidably disposed within the bores 18 and 20. One end of mounting rod 26 carries a yoke 28 and the opposite end thereof terminates in an extending shoulder 30. The rod 26 further supports an extending retainer 32 for the engagement thereof by a spring 34 disposed between retainer 32 and web 16. The yoke 28 carries a shaft 38 for mounting an earth cutter 36 for engagement with the face, i.e., the surface, of the earth 40. Shoulder 30
insures that the rod end 24 will not remove from web 16, and spring holds cutter 36 in engagement with the earth 40, and 34 accommodates a displacement of the cutter 36, relative to the cutterhead 12, a distance indicated by "Z" in the figure. Accordingly, should the earth cutter 36 happen to engage a prominent outcropping 42 (as shown, for example) the spring 34 will allow it to yield and close upon cutterhead 12 so as to prevent excessive loading of the cutter 36.

In FIGS. 2, 3, and 4, earth cutter mounting means 44 is depicted as an alternate embodiment of a resiliently-constrained, rotatable earth cutter. The mounting means 44 here depicted comprises a cutterhead 12' to which is fixed a stanchion 46 by means of hardware 48. This stanchion 46 carries a torsion bar 50, which is keyed by key 52 at one end to the stanchion, and pinned to a cutter limb 54 by means of pin 56, to insure that either ends of the bar are locked against rotation. Shaft 38 carries the cutter 36 rotatably thereon.

In response to a severe loading of core-engaging cutter 36, the bar 50, acting as a torsional spring, twists to allow cutter 36 to yield. The cutter 36 rotates about the axis of shaft 50, closing upon the cutterhead, to prevent destructively, high loading thereof.

Another alternate embodiment of earth cutter mounting means, according to our invention, is shown in FIG. 5 where the mounting means 60 comprises a fluid-powered means for holding the earth cutter 36 in engagement with the surface or earth 40. Again, in this embodiment, a stanchion 62 supports a limb 64 by means of a pivot pin 66. Therefore, in this embodiment, limb 64 is freely rotatable relative to the stanchion 62. A hydraulic-fluid-powered ram 68 is fixed to the cutterhead 12 (by means not shown) so that the plunger 70 thereof extends therefrom into engagement with the limb 64.

Simply by charging ram 68 with hydraulic fluid, by means well known in the art (and warranting no specific explanation here), the cutter 36 is constrained against the earth 40. In provisioning means which will relieve ram 68 of fluid, when cutter 36 encounters prominent outcroppings of earth, the cutter 36 will be protected against excessive loading. Our invention comprises such means, and, of this, more is explained in the ensuing description.

Still another alternate embodiment of novel earth cutter cutting means, according to our invention, is illustrated in FIG. 6. Here, too, this novel mounting means 72 is hydraulic-fluid-powered and comprises a stanchion 76 to which a limb 78 is freely-pivoted. A ram 80, again, is fixed to the cutterhead 12' in such a manner that the plunger 82 thereof may engage the limb 78 to effect movement of the earth cutter 36. In this embodiment, an end of the cutter shaft 38 extends projecting from the cutter 36 and is slidably engaged with a guide 84 fixed to the cutterhead 12', the guide having a slot 86 formed therein for accommodating relative movement of the end of the shaft 38 therewithin.

In FIG. 7 is illustrated yet another hydraulic-fluid-powered earth cutter mounting means, according to our invention, in which the mounting means 88 incorporates a stanchion 90 which is fixed to the cutterhead 12' and a ram 68 which, in this embodiment, is fixed (by means not shown) to a limb 64'. In this embodiment, the limb 64' operates somewhat like a bellcrank. The plunger 70' carries a clevis 92 at one end thereof which cooperates with a pin 94 coupled to limb 64' to effect a bellcrank motion of limb 64'. By hydraulic-fluid-powered translating extension of plunger 70', limb 64' is rotated about pivot pin 66 to cause the earth cutter 36 to move into engagement with the earth surface 40.

Yet another embodiment of an earth cutting mounting means, according to our invention, is depicted in FIG. 8. This mounting means 96 also incorporates the use of a stanchion 62' which pivotally carries a limb 98 by means of a pivot pin 66. In this embodiment, ram 80 is carried by the limb 98 in a manner which disposes the plunger 82 for engagement with the cutterhead 12'. In spite of this inversion of the ram 80, as compared to the arrangement in FIG. 6 for instance, it is quite clear that in this embodiment, as in all the other embodiments, the movement of cutter 36 away from cutterheads 12 (and 12') is effected by a reaction from the cutterhead.

In this latter embodiment, we set forth means comprising a limit stop 100 for inhibiting an excessive movement of the cutter 36 outwardly from the cutterhead 12'. Limit stop 100 has a depending tang 102 which engages a lip 104 extending from limb 98. Therefore, ram 80 is limited to effecting only a given outward displacement of cutter 36 (relative to cutterhead 12'). Any one or all of the embodiments depicted in FIGS. 5 through 8, the same comprising hydraulic-fluid-powered rams, can be made operative by the hydraulic fluid supply and distribution system illustrated schematically in FIG. 9. This system comprises a plurality of rams 106 (representative of rams 68 and 80) which are coupled in parallel by means of a manifold 108 to a hydraulic fluid supply line 110. The other end of the supply line 110 terminates in a reservoir 112 by way of a pump 114. Line 110 is also in direct communication with an air-over-oil accumulator 116, whereas its termination at (pump 114 and) reservoir 112 is through a relief valve 118. Accordingly, when the cutters 36 are all addressed to a surface of earth 40, the hydraulic fluid supply, by way of manifold 108, will cause all cutters to address the earth face uniformly, in synchronism. However, if a prominence such as outcropping 42 (FIG. 1) is presented to one of the cutters, that one cutter can retract and yet remain under a substantially constant thrust load, a thrust load which is substantially equal to the thrust loading on the other cutters.

To explain: if the one cutter among several, alone, encountered the outcropping, and were it unyieldably fixed on the cutterhead, its thrust loading, prior to any optimum level, would rise sharply, critically, probably destructively. All the other cutters — even though they too are unyieldably fixed on the cutterhead — would experience a reduced thrust loading. Through our inventive teaching, the one, heretofore destructively loaded cutter can yield before the increasing thrust loading and, through manifold 108, cause all other cutters, perhaps five other cutters, in parallel-fluid connection therewith to share the increased thrust load. Assume that the one cutter, priorly under an optimum loading represented by the arbitrary factor of 100, addresses a loose rock or outcropping so that its loading would normally be expected to escalate upwardly to a factor of 400. The one "burdened" cutter will displace hydraulic fluid back into the accumulator. All six cutters then, will share equally of the burden. All six cutters would each come under a loading of a factor of perhaps the optimum 100, or perhaps slightly more.
The one so-called "burdened" cutter, if met with an outcropping, would yield a given distance, forcing the hydraulic fluid to the accumulator; and the other five cutters would substantially hold their positions relative to the cutterhead.

The reverse is true also. That is, when one (or more) cutter encounters a softer work face than the other cutters with which it is manifolded, manifold 108, in cooperation with the accumulator 116, allows the other cutters to yield, and retract from the relatively harder work face, and insure a maintenance of a substantially, optimum loading on every one of the manifolded cutters.

Rams 106 have fluid ports 109 which comprise constricted orifices. The ports are so defined to inhibit a too rapid evacuation and/or charging of the rams 106. Thus, the ports 109 cooperate with a relief valve 118 to prevent both unduly accelerated depressurization (and pressurization) of rams 106, and a resulting too rapid retraction (and advance) of cutters 36.

In the system shown in FIG. 9, the hydraulic fluid accumulator 116 maintains a relatively constant pressure on the rams 106. The pump 114 is provided to control and establish the hydraulic pressurization of the manifold 108 and to provide for fluid make-up.

A somewhat modified and alternate embodiment of a hydraulic fluid supply and distribution system, operative for powering the earth cutter mounting means of FIGS. 5 through 8, is shown in FIG. 10 where the rams 106 are coupled by way of manifold 108 to a servo valve 120. Valve 120 is operative to allow hydraulic fluid to be supplied under pressure to the rams 106 only when it is determined by a position sensor 122, that the rams' disposition warrants this. A feed-back loop 124 couples the sensor 122 to servo valve 120. Accordingly, if plungers 128 are in such a disposition (i.e. retracted or extended too far) that warrants the fluid-charging or fluid evacuation of the rams, the fluid servo valve 120 effects operation of pump 114 and a resultant charging of the rams with fluid from reservoir 112 or an evacuation of fluid to the reservoir.

Relief valves 126 are interconnected with the rams 106 and the reservoir 112 to dispose of any rapidly surging pressures of fluid.

The plungers 128 carry pistons 130 sealingly and slidably within variable-volume chambers 132 so that admittance of pressured hydraulic fluid into line 110 will, ordinarily, cause all of the plungers 128 to advance uniformly, in synchrony. However, should the surface of rock 40 present a prominent outcropping (such as 42, in FIG. 1) to one of the cutters 36, the plunger positionings are altered automatically. The one cutter encountering the outcropping will retract therefrom, as it proceeds to roll over the obstruction. Consequently, the plunger 128 thereof moves into its respective chamber 132, displacing the piston 130 a given "N" distance, as signified by the dashed-line positioning in FIG. 10. Some of the hydraulic fluid disposed before the N-distance displaced piston is forced therefrom to course through line 108 and then into the chambers 132 of the other manifolded rams 106. Each of the pistons 130 of the other rams 106 are displaceable, in a direction opposite to that of the N-distance displaced piston, a shared small fraction of the initial "N" displacement. Such fractional displacements "N/X" are depicted by dashed lines in FIG. 10. Conceivably none of the pistons 130 of the other rams 106 will displace (advance), or perhaps but one or two thereof will do so. Just what will occur with each depends on the nature of the surface to which each of the respective cutters 36 is then addressed, and the resultant loading impressed on each cutter. However, this may be, the system of FIG. 10 will insure against an excessive loading of any single cutter, and will substantially equalize the loading of all cutters, whatever be the nature of the surface of rock 40 being encountered.

To prevent an excess of fluid pressure in rams 106, sensors 122 cause operation of valves 126, whenever a plunger 128 moves a greater distance than in the yielding or retraction direction, to allow fluid to drain from manifold 108. Conversely, if a cutter encounters a depression or a relatively soft work face, and advances from the cutterhead, a distance in excess of N, its sensor 122 and valve 126 will respond. In such latter circumstance, the excessive advance of the cutter will drop the pressure in the respective chamber 132. The governing sensor will note the excessive travel of the plunger 128 and cause the associated servo valve 120 to return the pressure of the system to the optimum level.

The array of cutters 36, of whatever number, in being reactively urged from their respective cutterhead (12 or 12') cooperate to define a "cutting profile" which, for example is shown in FIG. 9 as linear and uniplanar. Now then, it is within our novel teaching to set forth earth cutter mounting means which comprises an enabling hydraulic fluid supply and distribution system, such as one of those depicted in FIGS. 9 and 10 as exemplary, and which is cooperative with a reactive thrust surface, such as cutterheads 12 or 12' to adjust the cutting profile, variously and successively, to conformity with an uneven surface of earth with which the profile is brought into forceable engagement, that no one or more of the cutters 36 will become excessively loaded. Consequently, our teaching presents novel earth cutter mounting means which insures a substantially averaged or equalized loading of all cutters, in a plurality of thrust-surface-mountable cutters, with the forceful address of the plurality to an earth face of indeterminate and/or varying surface configuration.

While we have described our invention in connection with specific embodiments thereof, it is to be clearly understood that this is done only by way of example and not as a limitation to the scope of our invention as set forth in the objects thereof and in the appended claims.

We claim:

1. In combination, earth cutter mounting means, comprising:

a plurality of earth cutters, and mountings therefor adapted to be mounted, in common, on a thrust member for urging said cutters into operative contact with earth; wherein each of said cutters is movably connected to its mounting, for movement toward and away from the thrust member; pressure means for each cutter, cooperative with said mountings, for yieldably urging the associated cutter away from the thrust member; and means cooperative with said pressure means for maintaining relatively constant and uniform the urging force applied by said pressure means to each of the associated cutters.
2. Earth cutter mounting means adapted to be mounted on a thrust member, comprising:
means for cutting earth; and
means coupled to said cutting means adapted for mounting said earth cutting means to a thrust member;
said mounting means including means for effecting movement of said earth cutting means relative to said mounting means and a forced address of said cutting means, from a thrust member, into thrust loading engagement with earth; wherein
said movement and forced-address effecting means comprise means operatively reactive, in response to an excessive thrust loading engagement of said cutting means with earth, to effect a relief of said excessive loading of said earth cutting means
said earth cutting means comprises a plurality of rotatable earth cutters;
said mounting means comprises means for rotatably mounting each rotatable earth cutter of said plurality thereof separately to a thrust member; and
said reactive means includes means, responsive to a forceable engagement of said earth cutters with earth for substantially equalizing the force with which each of said cutters effects forceable engagement.
3. Earth cutter mounting means, according to claim 2, wherein:
said reactive means comprises fluid-powered motor means disposed for engagement with said thrust member, upon said mounting means being adaptively fixed to a thrust member.

4. Earth cutter mounting means, according to claim 3, wherein:
said motor means comprises a hydraulic-powered ram.

5. Earth cutter mounting means, according to claim 2, wherein:
said mounting means comprises means accommodating for movement of said cutters into positions of greater and lesser proximity relative to a thrust member, upon said mounting means being adaptively fixed to said thrust member.

6. Earth cutter mounting means, according to claim 2, wherein:
said reactive means comprises means operative for relieving an excessive thrust loading force with which at least one of said cutters engages rock while increasing a thrust loading force with which at least another of said cutters engages earth.

7. Earth cutter mounting means, according to claim 6, wherein:
said force relieving and force-increasing means are substantially simultaneously operative.

8. Earth cutter mounting means, according to claim 2, wherein:
said reactive means comprises means operative both for diminishing the force with which at least one of said cutters engages earth by a factor of a given value and for increasing the force with which each cutter in a plurality of said cutters, other than said one cutter, engages earth by a factor of less than said given value, simultaneously.

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