Presented is an underground cable laying apparatus that leaves virtually no scar in the turf under which cable, wire, line, hose, etc. is laid. The apparatus utilizes a pair of angularly displaced turf slicing wheels to slice and separate the turf forming a slit into which cable may be laid. A cable guide tube and roller properly place the cable within the slit. A pair of turf closure wheels close the slit in close proximity to the release point of the cable to ensure proper placement of the cable. The slit in the turf is gently and completely closed over the cable, leaving virtually no visible scar within the turf to upset the aesthetic beauty of a lawn. Further, the configuration and rolling action of the turf slicing wheels ensures that other underground cables will not be damaged if inadvertently encountered.
FIG. 13
UNDERGROUND CABLE LAYING APPARATUS

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS


FIELD OF THE INVENTION

[0002] This invention relates generally to apparatuses and methods for laying underground cable or irrigation tubing.

BACKGROUND OF THE INVENTION

[0003] Aesthetics have always played an important role in home design and landscaping. Indeed, most homeowners take pride in the appearance of their yards and landscaping, often devoting many hours each weekend to ensuring that their lawn and garden look attractive and uncluttered.

[0004] Unfortunately, the necessities of day-to-day living often result in the use and installation of unsightly equipment. For example, the use of a garden hose and sprinkler to water the lawn and garden, the use of a fence to contain a pet, the running of cables and wires for lighting, cable TV, internet services, etc. all are visibly unappealing to many homeowners. The solution of choice for many homeowners is to run such cables, wires, pet containment systems, sprinkler systems, etc., underground so as to be hidden from view while still allowing the homeowner to reap the benefits provided thereby.

[0005] To run each of these varied systems underground, in the past, trenchers have been used to dig a small trench in the yard into which is laid the cable, wire, pipe, etc., for the particular system being installed. The soil removed from the trench is then put back in over the wire, cable, pipe, etc. In this way, each of these systems, wires, cables, etc., are hidden from view.

[0006] Unfortunately, this solution to the aesthetic problem has resulted in an underground maze of wires, cable, pipes, etc., for which no coordinated mapping is typically provided. Further, utility marking services such as JULIE do not provide marking of such consumer-installed underground cables, wires, pipes, etc., instead only marking the main utilities of gas, electric, water, etc. As a result, the attempted installation of subsequent underground systems using a trencher often results in damage or breakage of the underground lines, cables, wires, pipes, etc., of previously installed underground systems. This not only results in frustration of the homeowner as the affected system may no longer be used until it is repaired, but also additional expense for the installers of the subsequent underground systems who have caused the damage and now must bear the expense of repair. Additionally, the type of damage resulting from the use of current methods for underground cable laying often results in multiple breaks in the underground system. That is, oftentimes the underground line, cable, wire, pipe, etc., is snagged by these trenching apparatus and pulled along until a failure occurs in the affected system. Such failures may be at locations other than the point at which the system was snagged by the trencher, often requiring a large portion of the damaged underground system to be dug up to effectuate the repair at the locations of the break.

[0007] A further disadvantage with current methods for laying underground cable, wire, flexible tubing, etc., is that the current methods leave a visible scar in the yard. This scar typically requires the planting of additional grass or other ground cover seed, which further increases the expense, detracts from the aesthetics which it was meant to protect, and requires additional lawn care to properly water the newly planted seed to ensure germination and full growth to fully hide the trencher scar.

[0008] The above-mentioned problems, and desires, are not limited to residential installations, but are also encountered in institutional and commercial settings. For example, a great deal of care is often lavished on establishing and maintaining healthy turf on athletic fields, used for playing football, baseball, soccer, or other outdoor sports. Large grassy areas, forming part of the landscaping around commercial buildings, in public or private parks, and on golf courses, are also examples of places in which it is often necessary, or desirable, to provide complex underground irrigation installations, or to run cable for electric power, communication, lighting systems, or heating systems under the surface of the turf.

[0009] Where it becomes necessary, or desirable, to run additional cables or tubing through an area of established turf, it is desirable that such additional cables or tubing be installed in a manner which does not leave a visible scar in the existing turf, or damage underground cable or tubing which is already in place under the turf.

[0010] Previously available equipment and methods have not proved to be entirely satisfactory in alleviating the above-mentioned problems, and in meeting the above described desires. For example, in one piece of equipment currently being marketed for installation of subsurface dripperlines in turf grass, a multi-blade lawn plow includes a vertically mounted coulter wheel, for slicing through the turf of a football field, or the like, followed by a ripper blade extending below the coulter wheel, and having a passage therein for feeding dripperless irrigation tubing into the ground behind the ripper blade. The lawn plow further includes a pair of tamping feet mounted adjacent the ripper blade for compacting the soil after the dripperline has been buried. The entire multi-blade plow apparatus is mounted on a frame, which is in turn attached to a vibrating mounting arrangement of a trenching-type machine. Where the subsurface installation includes existing underground cabling and/or tubing, the ripper blades of the multi-blade lawn plow will, in all probability, catch and cut, or otherwise damage, the existing underground installation. The narrow, relatively sharp edges of the vertically oriented coulter wheels may also cut or damage the existing underground installation. It is, therefore, unlikely that such a multi-blade lawn plow could be utilized for installing cable or dripperline irrigation tubing in a turf grass installation having existing underground heating cables, for example.

[0011] It is also not likely that such a multi-blade lawn plow could be utilized for laying dripperline irrigation tubing over the top of an existing irrigation tubing system, supplying traditional sprinkler heads, for example, without prior removal of the existing sprinkler tubing. Attempts to utilize such a multi-blade lawn plow for laying the dripperline irrigation tubing under the surface of the ground on top of the existing tubing feeding traditional sprinkler heads
would likely result in the ripper blades catching on the previously installed irrigation tubing, and thereby causing significant damage to the turf grass surface as the existing tubing is pulled along by the ripper blades.

In addition to the above-mentioned problems with utilizing previously available trenching equipment and lawn plows, such as leaving a visible scar in the turf, and/or cutting, catching, or otherwise damaging previously installed underground facilities, there are further difficulties which must be overcome, in placing underground cable, wire, line, tubing, etc. under a turf surface. For example, cable, of the type utilized in cable television installations, is typically supplied on reels having a relatively small diameter. As a result of the relatively small reel diameter, the cable tends to develop a shape memory which will cause it to attempt to re-coil itself, and, in the process, spring upward out of the ground, if it is not secured by a significant amount of soil pressure. In addition, care must be taken to ensure that the cable is not kinked, damaged by abrasion, cut, or overly strained while being guided into the soil under the turf. In this regard, it is necessary that the bend radii imposed by application equipment be relatively large. As a further complication, the outer surfaces of the cable, and/or tubing, etc., being laid is of a nature which can create substantial frictional force against various structures of an apparatus being utilized for installing the cable and/or tubing. If the frictional force of the laying mechanism, together with any resistance to movement through the apparatus by changing the direction of the cable, is not kept relatively low, the laid cable or tubing will be dragged along with the placement machine, rather than remaining where it is laid down under the turf.

Maintaining the health and appearance of the turf during and subsequent to installation of the cable or tubing also requires considerable care. It is necessary, for example, to close any opening made for laying the cable or tubing quickly enough, and with properly applied closure force so that exposure of the roots to drying and sunlight, will be minimized, and in such a manner that effective contact of the roots with surrounding soil will be reestablished following closure of the opening in the turf.

Through consideration of the above described problems and desires, the inventor of the present invention came to recognize that an improved apparatus, differing substantially from those previously known, would be required. In this regard, the inventor determined that an apparatus and method utilizing equipment for cutting a slice through the turf by action of a rolling element would be preferable to previously known approaches using ripper blades or other types of traditional trenching equipment.

The inventor further recognized that the nature of the turf itself, when subjected to slicing in an appropriate manner, could be used to significant advantage in developing a new and improved apparatus and method for laying underground cable, wire, line, tubing, etc. For example, unlike loose or bare soil, turf tends to sprout back, of its own accord, to close any slits cut therein. Turf also tends to hold loosened soil in place, within the roots, rather than allowing the soil to be moved upward onto the surface of the ground.

The inventor also observed that even a relatively shallow-rooted layer of turf, such as freshly laid sod, provided substantial resistance to having a cable pop back out of the ground, once the turf and soil was compacted back into place over the laid cable or tubing. This was observed to be particularly the case in well-watered turf.

Having concluded that traditional trenching equipment and methods were unlikely to provide an improved apparatus and method, solving the problems and meeting the desires laid out above, the inventor considered a variety of other solutions, including the use of various structural aspects of equipment utilized for planting seeds through both conventional and reduced or zero tillage methods. Such seed planting equipment has traditionally included the use of one or more rolling coulters, in conjunction with some form of seed feeding tube or structure, and a closure device, for creating shallow V-shaped furrows into which the seed is deposited.

Such traditional seed-planting type equipment is not suitable for use, however, or readily adapted for use, in laying underground cables or tubing, under turf.

As illustrated in FIGS. 7a and 7b, the rotating coulter A, or coulters, of seed planting equipment is typically designed for rather shallow penetration into the soil, to provide a V-shaped furrow, which extends only a limited distance D below the surface of the ground G, with the depths of such furrows typically being in the range of 1-4". The actual depth D will be determined by the particular type of seed being sown, but in general, the seed must be kept within a limited distance of the top of the ground G, in order for the plant emerging from the seed to reach and extend above the surface G of the ground, and begin producing energy through photosynthesis, prior to the nutritional reserves in the seed itself being exhausted. Stated another way, it is necessary to place seed relatively close to the ground surface B, in order for the seeds to germinate properly and survive. The shallow depth D of the V-shaped furrow produced by seed planting equipment is therefore considerably less than the depth, for example 5-10", at which it is desired to lay underground cable or irrigation tubing.

In order to create the V-shaped furrow desired for seed planting, a typical seed planting apparatus often utilizes multiple coulters A or disks having a point of contact C with one another that is located at a considerable distance below a center B of the coulter A or disk, with the coulter A or disk angling outward vertically above and horizontally aft of the point of contact C. The point of contact C is often selected to correspond with the ground level G, when the seed planting mechanism is penetrating the soil and forming a V-shaped furrow of the desired depth D.

As illustrated in FIG. 7a, this results in the depth D of the V-shaped furrow being substantially less then the radius R of the coulter or disk A. For example, in an apparatus disclosed in U.S. Pat. No. 5,724,902, two disk blades are positioned to form a V-shaped furrow opener with a contact point between the disks 20 and 22 being located substantially at an angle of 35° from the vertical axis (i.e. an angle of 55° down from the horizontal axis passing through the center B of the disk A). One of the disks is smaller, and is mounted vertically with no inclination. The larger of the two disks is inclined 6° along an axis extending through the contact point and the larger disks center, to thus form a compound angle in both the vertical and horizontal planes. By virtue of this arrangement, the tangency or contact point
of the two disks is located approximately 1.25" above the lower edges of the disks, and is thus located at the soil surface when the seeding tool is operated at a planting depth of 1.25".

[0022] In similar fashion, U.S. Pat. No. 4,493,274, discloses a pair of forming disks having a 14" diameter and staggered longitudinally by 1°, fore and aft with respect to one another, and the axes inclined so that the included angle is 9.5° and the disks substantially contact each other at a point forward of their axes at about 38° downwardly from the horizontal. By virtue of this arrangement, the 14" diameter disks create a furrow having a 2.69" depth, when the point of contact is located at the surface of the soil.

[0023] Because of the point of contact C is located so low on the disks A of prior seed planting equipment, and as a result of the disks A being angled with respect to one another and diverging upward of the point of contact, if such seed planting equipment were forced deeper into the ground, the disks A would cease to function properly, with the individual disks A each cutting a separate slit into the soil at the surface G of the ground, while leaving undisturbed soil in the space between the upwardly diverging edges of the disks A.

[0024] An additional problem preventing the use of prior seed-planting equipment for laying of cable or tubing stems from the fact that such seed-planting equipment is typically designed for use only in relatively loose, non-turf applications. This is true, even for so-called reduced tillage planting equipment. In general, the rotating coulters or disks of a seed-planting apparatus are utilized to cut through the soil, and by virtue of the compound angling of the disks, to remove the soil from the furrow and deposit it onto the ground alongside the furrow, so that the seeds may be placed into the vertex at the bottom of the V-shaped furrow. The seed-planting apparatus typically includes a closure mechanism which moves the soil removed from the furrow back into the furrow, to close the furrow, and firm the soil over the seeds to provide good soil contact with the seed in the furrow and to crush the sides of the furrow to provide a loose layer of soil over the seeds, in the manner described, for example, in U.S. Pat. No. 5,092,255. For proper germination of the seed, soil contact is required, but it is also desirable that the soil not be overly compacted to the point where the plant emerging from the seed will be prevented from reaching the surface of the ground and emerging from the furrow.

It will be noted, by those having skill in the art, that the seeds are also individual elements, which are individually placed into the furrow, in stark contrast to a continuous length of cable or tubing which may have a shape memory tending to cause it to coil spring back out of the ground, or otherwise move during the process of being laid into the soil. The loose nature of soil placed back into the furrow by a closure and firming apparatus of a seed planter is thus not designed, and is totally inadequate for compressing the soil over a cable or irrigation tube to the degree required for subsurface cable or tubing installation, particularly when laying cable with a shape memory tending to cause the cable to re-coil and pop out of loosely packed or firmly soil.

[0025] As previously stated, prior seed-planting equipment, including so-called zero-tillage or reduced-tillage planters are not designed for use in turf applications. Trash remaining on the surface of the soil, or clumps of turf will typically result in substantial interference with the operation of typical planting equipment. In order to deal with this problem, it is common practice for prior seed-planting equipment to include various types of trash cutting blades ahead of coulters used for making a furrow in the soil. Such trash cutting devices have included, for example, a wave-edged coulter wheel for slicing up and disburting any trash or clumps of turf in the path of the furrow-forming coulter wheel. Such trash cutting and disburting devices leave unsightly scarred areas in turf, and would be totally antithetical to the purposes of the present invention. It is noted that in some prior types of planters, used for placing seed into grassy surfaces of a pasture, or the like, single vertical coulters are utilized for cutting a very shallow (less than 1" deep, for example) furrow into the ground with the seed being deposited therein, as part of an apparatus commonly known as a drill, rather than a planter.

[0026] The seed delivery tubes, of the type used in seed planting equipment, are also typically designed to extend substantially vertically, in order to maximize delivery rate of the seed into the furrow. As disclosed in U.S. Pat. No. 6,347,594 B1, curved delivery tubes tend to cause reduced delivery rate, and are thus typically not utilized in seed planting equipment. Vertical, non-curved delivery tubes, of the type typically used in seed planting equipment, would be highly undesirable, and essentially unworkable, for feeding cable or tubing. Such a vertically oriented, non-curved configuration, would not lend itself at all to smoothly feeding cable or tubing into the ground in a horizontal direction, behind a coulter wheel or wheels, in a manner which did not create excessive drag within the delivery tube, or other adverse affects such as straining, scraping, or kinking of the cable or tube at the point where it must make a transition from the end of the essentially vertically oriented delivery tube into the horizontal resting position it must assume at the bottom of the furrow created by the coulter wheels.

[0027] Prior seed-planting apparatuses also do not include any structure or device capable of holding a cable or tube stationary within the bottom of a trench or furrow, while the trench or furrow is closed and the soil compacted sufficiently around the cable or tube to prevent it from springing out of the trench or being dragged along with the cable-laying machine. Although some prior seed-planting machines include provisions for precluding having the seed bounce out of the furrow, prior to being covered, these devices would not be useful for holding a cable or tube in place, in accordance with the requirements of the present invention. For example, in U.S. Pat. No. 4,253,412, to Hognson, a series of plates are joined together by pairs of links and attached behind the discharge end of a seed delivering boot. The plates of Hognson are not capable of exerting any appreciable downward force for holding a cable or tube in place, in the manner required by a cable laying apparatus. U.S. Pat. No. 5,092,255, to Long et al., and U.S. Pat. No. 5,918,557, to Schaffert, disclose seed boot extensions for reducing seed bounce and to help direct bouncing seeds into the vertex in the bottom portion of a V-shaped furrow. The boot extensions of Long and Schaffert are formed from a flexible material, in order to allow the boot extension to ride up over any chunks of soil within the furrow. The extensions of Long and Schaffert would not apply sufficient force for holding a cable or tube; in accordance with the requirements of the invention. In addition, the extension of Schaffert is
supported at a distance above the furrow, for deflecting seed back into the furrow, but does not contact the furrow or seed continuously.

[0028] U.S. Pat. No. 5,673,638, to Keeton, discloses a resilient seed firming attachment for a planting machine having a free end, which is cylindrically shaped, or otherwise configured into a shape such as an inverted V shape substantially conforming to the furrow shape, for positioning seed kernels into the furrow apex. Given the downwardly convex shape of the seed forming attachment of Keeton, it will be apparent, to those having skill in the art, that the seed firming attachment of Keeton would not be usable for holding a cable or tube in place, in accordance with the requirements of the invention. Specifically, the downwardly convex surface of the seed firming attachment of Keeton would not remain positioned on top of the upwardly convex surface of the cable or tubing, but would tend to slide off of the upwardly convex surface of the tubing, or would allow the cable or tubing to slide outward and upward around the firming attachment of Keeton. As a result, the cable or tube would not be held in place, and would likely be pulled upward out of the ground and potentially be wrapped around the firming attachment of Keeton.

[0029] As a final point of inadequacy of prior seed-planting apparatuses to be utilized for, or to be readily adapted for, laying a cable or tube, it will be noted that the furrow closure and firming arrangements of seed-planting apparatuses have typically been positioned at a relatively long distance behind the coulters utilized for making the furrow. This elongated spacing would make it more difficult to achieve the various requirements of the present invention, such as quickly closing the turf, after insertion of the cable or tubing, and compacting the turf and soil over the laid cable or tubing to a degree sufficient to hold it in place within the soil and preclude having the cable or tube being drawn through the soil with the apparatus used for installing the cable or tube under the turf.

[0030] There exists, therefore, a need in the art for a new and improved underground cable, wire, line, tubing, etc., laying apparatus and method that substantially reduces or eliminates the risk of breaking other underground systems, and which does not leave a visible scar in the yard that requires additional care and expense to correct.

**BRIEF SUMMARY OF THE INVENTION**

[0031] The term “cable”, as used herein, with regard to describing the present invention, is intended to be construed broadly to include not only cable, but also line, wire, hose, fiber optic cable, tubing, etc., or the like, that one may desire to vary under the surface of the ground, and in particular, under the surface of soil having turf growing thereon.

[0032] The present invention provides a new and improved underground cable and the like laying apparatus. More particularly, the present invention provides a new and improved underground cable laying apparatus that is capable of crossing without damaging other underground cables and the like. Further, the present invention provides a new and improved underground cable laying apparatus that does not leave a visibly obvious scar in the lawn under which the cable has been laid.

[0033] In one form of the invention, an underground cable laying apparatus includes a mounting yoke, a pair of angularly displaced turf slicing wheels, and a cable guide tube. The pair of angularly displaced turf slicing wheels are rotatably coupled to the mounting yoke, in such a manner that the turf slicing wheels define a forward contact area therebetween. The cable guide tube is positioned aft of the forward contact area of the turf slicing wheels, with the cable guide tube further having a cable inlet and a cable outlet.

[0034] In an underground cable laying apparatus, according to the invention, each of the angularly displaced turf slicing wheels may define a radius and an outer periphery thereof, and be mounted for rotation about a respective turf slicing wheel axis directed such that, when viewed from either side of the apparatus, the outer peripheries of the turf slicing wheels are substantially super-imposed upon one another vertically and horizontally, with the peripheries coming together at a point of contact in the forward contact zone and disposed substantially horizontally forward of the axes of the turf slicing wheels. The point of contact may be angularly positioned within a range of zero to twenty degrees down from a horizontal extension of the axes of the turf slicing wheels. In some forms of the invention, the point of contact may be vertically positioned substantially horizontally level with the axes, and substantially at ground level when the apparatus is slicing the turf, such that substantially the entire radius of the turf slicing wheels is disposed below ground level in operation. The pair of turf slicing wheels may be angularly displaced relative to one another along a vertical axis of the mounting yoke, in such a manner that the forward contact area is disposed substantially below the point of contact, and the outer peripheries of the turf slicing wheels diverge below the forward contact area, in such a manner that the slit in the turf has a defined horizontally extending bottom width thereof, rather than being substantially V-shaped and terminating in a vertex of the V-shape at the bottom of the slit.

[0035] In accordance with one embodiment of the present invention, the underground cable laying apparatus includes a pair of angularly displaced turf slicing wheels that slice and separate the turf under which the underground cable is to be laid. A cable feed tube is positioned between the turf slicing wheels to guide the underground cable between the turf slicing wheels. A cable feed guide wheel is positioned rearward of the opening of the cable feed tube to aid in the positioning and proper laying of the underground cable in a smooth fashion. In a preferred embodiment, the leading edge of the cable feed tube includes a feed tube support extension member to provide additional rigidity and stabilization of the cable feed tube placement while laying the underground cable. A cable guide wheel cleaning mechanism can be applied to prevent the build up of soil on the guide wheel. A cable guide may also be employed at an insertion end of the cable feed tube.

[0036] In a preferred embodiment of the present invention, the underground cable laying apparatus also includes turf closing wheels operative to close the slit in the turf into which the cable has been laid. These turf closing wheels are carried by a turf closure housing that is pivotally coupled to the mounting yoke of the cable laying apparatus. Preferably, the turf closing wheels are spring loaded by a turf follower spring within the turf closure housing. This turf follower
spring is preferably adjustable to vary the spring load tension on the closing wheels based upon the type of lawn under which the cable is to be laid. Positioning detents or blocks limit the downward travel of the turf closure housing under action of the turf follower spring.

[0037] In a preferred method of laying underground cable, and the like, in accordance with the teachings of the present invention, a thin slice in the turf is opened by the turf slicing wheels. Preferably, the soil is moist, either from natural sources or from a step of watering. Cable or the like is then positioned within the open slice in the turf. Preferably, this step is accomplished by guiding the cable to be laid into the slice in the turf. This step of guiding may be accomplished in a preferred embodiment through the use of a cable feed tube having at an aft end thereof a cable guide, which may take the form of a wheel, roller, guide bar, etc., configured for maintaining the cable in the proper position within the slice in the turf.

[0038] A cable guide, according to the invention, may take a variety of forms having a downwardly facing, non-convex surface thereof adapted for contacting the cable. Such a non-convex contact surface may be flat, concave, and may include a groove therein for partial receipt within the groove of the cable. Alternatively, or in addition, the cable guide may be formed of a flexible material having the ability to conform to the upwardly convex upper surface of the cable. In some forms of the invention, the cable guide may take the form of a flexible segment of tubing, leaving a bore therein for passage therethrough of the cable, with a lower end of the cable guide being directed, or flexibly movable by virtue of contact with the bottom of the slice in the turf to expel the cable in a substantially horizontal direction into the bottom of the slice in the turf.

[0039] Preferably, the method of laying underground cable in accordance with the present invention also includes the step of closing the slice in the turf once the cable has been laid therein. This step may be performed by providing a closing force in a direction to close the slit. Preferably, this closing force is applied to either side of the slit to preclude damage to the turf under which the cable has been laid.

[0040] Through the method of the present invention, damage to other underground systems, such as invisible fencing, other cables or wires, or sprinkler systems is precluded or the likelihood of such is significantly reduced. This is so because the rolling action of the turf slicing wheels does not snag or otherwise cut the other underground wires as occurs within the prior art methods of laying cable. As such, a significant advantage is realized through the use of the present invention for laying underground cable and the like. Similarly, by opening a thin slice in the turf which is then closed by applying a force to either side of the slice, the unsightly scarring of the turf that commonly results with prior art methods is also precluded.

[0041] Other aspects, objectives and advantages of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0042] The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention and, together with the description, serve to explain the principles of the invention. In the drawings:

[0043] FIG. 1 is a side view illustration of an embodiment of an underground cable laying apparatus constructed in accordance with the teachings of the present invention;

[0044] FIG. 2 is a cross-sectional illustration of the cable laying apparatus of FIG. 1;

[0045] FIG. 3 is a frontal isometric view of the cable laying apparatus of FIG. 1;

[0046] FIG. 4 is a rear isometric illustration of the cable laying apparatus of FIG. 1;

[0047] FIG. 5 is a cross-sectional illustration of the cable laying apparatus of FIG. 1 shown in operation laying an underground cable;

[0048] FIG. 6 is a partial isometric illustration of a cable feed guide wheel assembly of the cable laying apparatus of FIG. 1;

[0049] FIGS. 7a and 7b are schematic illustrations of a typical prior art seed planting mechanism, having one or more coulters arranged for cutting a V-shaped furrow in the earth, for deposition of seeds therein, with the illustrations further showing that the depth of such a V-shaped furrow below ground level is considerably less than a radius of the coulter;

[0050] FIGS. 8a-8c illustrate the manner in which the invention is utilized for cutting a non-V-shaped slit into turf-covered soil, with a pair of angled coulters, in accordance with the invention, in such a manner that the depth of the non-V-shaped slit is significantly larger than the depth of the V-shaped furrow formed by prior art devices and methods, with the depth of the slit, according to the invention, being substantially equal to the radius of the angled coulters;

[0051] FIGS. 9-11 illustrate several alternate embodiments of a cable feed guide wheel, according to the invention, as applied in the exemplary embodiment of the cable laying apparatus shown in FIGS. 1-6;

[0052] FIGS. 12 and 13 illustrate an alternate embodiment of a cable feed guide, according to the invention, having a downwardly opening substantially convex surface thereof for contacting an upper convex surface of a cable or tube being installed into turf-bearing soil;

[0053] FIG. 14 illustrates an alternate embodiment of the exemplary embodiment of the cable laying apparatus of FIGS. 1-6, which includes a cable feed tube having a flexible outlet;

[0054] FIG. 15 illustrates an alternate embodiment, according to the invention, of the apparatus shown in FIG. 14, with the apparatus of FIG. 15 including a flexible cable feed tube liner and extension; and

[0055] FIG. 16 illustrates an alternate embodiment, of the exemplary embodiment of the cable laying apparatus shown in FIGS. 1-6, with the alternate embodiment of FIG. 16 illustrating a pair of turf closing wheels having a flat, angled, contact surface thereof, as compared to the rounded contacting surfaces of the turf closing wheels shown in FIGS. 1-6.
While the invention will be described in connection with certain preferred embodiments, there is no intent to limit it to those embodiments. On the contrary, the intent is to cover all alternatives, modifications and equivalents as included within the spirit and scope of the invention as defined by the appended claims.

Detailed Description of the Invention

Turning now to the drawings, there is illustrated in FIG. 1 an exemplary embodiment of an underground cable laying apparatus 10 constructed in accordance with the teachings of the present invention. In the interest of brevity, the term cable will be used throughout this description to include cable, line, wire, hose, fiber optic cable, tubing, etc., that one may desire to bury under the surface of the ground.

As may be seen from this FIG. 1, the underground cable laying apparatus 10 includes a mounting yoke 12 on which is mounted a pair of turf slicing wheels 14, 16 (see FIG. 2). The mounting yoke 12 includes mounting receptacles, for example receptacles 18, 20 that are positioned and configured to allow the apparatus 10 to be mounted to a truck or other vehicle that will be used in the cable laying process. As such, the particular configuration and placement of the mounting receptacles may vary in particular embodiments based upon the type of vehicle used in the cable laying process. Indeed, the position and configuration of the mounting receptacles may accommodate the usage of an intermediate mounting or other equipment, for example a shaker unit, that may be directly mounted to the vehicle.

In addition to the turf slicing wheels 14, 16, a turf closing mechanism, for example turf closing wheels 22, 24 carried on a turf closure housing 26, is pivotably mounted to the yoke 12 by the closure assembly mounting arms 28, 30. The turf closure housing 26 may include positioning detents 32, 34, blocks, shoulders, or other movement limiting structure to prevent the turf closure wheels 22, 24 and their associated housing 26 from pivoting downward beyond a desired location. However, as will be discussed more fully below, the upward pivoting of the housing 26 is preferably unimpeded within a range to allow the turf closing wheels 22, 24 to follow the contours of the soil into which the cable has been laid.

The underground cable laying apparatus also includes a cable feed tube 36 used to guide the cable to be laid through the apparatus 10. To facilitate this operation, the cable feed tube 36 includes a cable inlet 38 at a forward location of the apparatus 10 that receives the cable from the spool or other holding device. If desired, the cable feed tube 36 may also include a cable guide 40 positioned above inlet 38. This cable guide 40 may have a diameter larger than the inlet 38 to allow for some play in the cable before it enters inlet 38. The cable feed tube 36 leads down between the turf slicing wheels 14 to a position rearward of the leading edges thereof. At this position the cable feed tube outlet 42 dispenses the cable to be laid in the slice in the turf which has been created by the turf slicing wheels 14, 16. At this outlet 42 a feed tube support extension member 44 may be provided to add additional stability and support for the end of the cable feed tube 36.

FIG. 2 provides a cross-sectional illustration of the underground cable laying apparatus 10 illustrated in FIG. 1. As may be seen from this cross-sectional illustration, the positioning of the cable feed tube 36 preferably provides a curved path through which the cable may be directed through the apparatus. In this way, the possibility of snagging or chafing the exterior of the cable to be laid is greatly reduced over prior systems that terminated in an outlet perpendicular to the trench into which the cable was to be laid. To further aid in the smooth and proper positioning of the cable within the slice in the turf created by the turf slicing wheels 14, 16, the apparatus 10 of the present invention may also include a cable feed guide, such as wheel 46. This cable feed guide wheel 46 is positioned in proximity to the outlet 42 to further place the cable in the proper position in the slice in the turf without scraping or otherwise damaging the exterior surface of the cable. Indeed, in embodiments that utilize this cable feed guide the cable feed tube may be straight with an outlet perpendicular to the slit as the cable feed guide will ensure a smooth directional change in the cable without damage thereto. To prevent the buildup of soil within the groove 48 of the cable feed guide wheel 46, a groove cleaning rod 50 may be provided. This groove cleaning rod 50 is positioned within the groove 48 of the cable feed guide wheel 46 in such a manner so as to prevent or reduce the amount of buildup of soil within the groove so that the cable being dispensed may be gently guided within the groove 48 to its proper position within the slit in the turf.

As may be also be seen from this cross-sectional illustration of FIG. 2, the turf closure housing 26 is spring-biased to its downward position by a turf follower spring 52. Preferably, this turf follower spring 52 is coupled between the mounting yoke 12 via a spring mount 54 and the rearward wall 56 of the turf closure housing 26, rearward of the pivot point 58. The amount of force that the turf closure wheels 22, 24 apply to the turf may be adjusted by varying the spring tension. In the embodiment illustrated in FIG. 2, this spring tension variation may be accomplished by adjusting spring tension nut 60. The adjustment of this spring tension is facilitated by the positioning detents 32, 34 as they prevent further downward pivoting of the turf closure housing 26 through their engagement with the closure assembly mounting arms 28, 30.

As may be seen from the frontal isometric illustration of FIG. 3, the turf slicing wheels 14, 16 are angularly positioned relative to one another. Preferably, they are angularly positioned relative to both the horizontal and vertical axis of the mounting yoke 12. That is, the turf slicing wheels 14, 16 are positioned such that they contact each other at a contact point 61 along an area 62, and are elsewhere displaced from one another. This displacement between the turf slicing wheels 14, 16 preferably increases both along a horizontal and vertical axis such that a small slice is initiated in the turf by the forward contact area 62, and is widened along both the horizontal and vertical axes as the apparatus 10 is moved through the turf. In this way, the turf defining the slit is displaced both outwardly and upwardly to accept the cable to be laid therein. With such a displacement of the turf defining the slit, the turf closure wheels 22, which provide an angular closing force on either side thereof, may then fully close the slit without damage to the turf. Indeed, in most situations the closure of the slit is complete without leaving a residual scar in the turf whatever. As may be seen from this frontal view of FIG. 3, the angular displacement of the turf closure wheels 22, 24 is

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preferably greater than the angular displacement along the same axis of the turf slicing wheels 14, 16.

[0064] As shown in FIGS. 3 and 8a, in the exemplary embodiment of the underground cable laying apparatus 10, each of the angularly displaced turf slicing wheels 14, 16 defines a radius R and an outer periphery thereof, and is mounted for rotation about a respective turf slicing wheel axis 17, 19 directed such that, when viewed from either side of the cable laying apparatus 10, (as depicted in FIG. 1, for example) the outer peripheries of the turf slicing wheels 14, 16 are substantially super-imposed upon one another vertically and horizontally, with the peripheries coming together at the point of contact 61 in the forward contact zone 62 and disposed substantially horizontally forward of the axes 17, 19 of the turf slicing wheels 14, 16.

[0065] As illustrated in FIG. 8a, by virtue of the above described attachment of the turf slicing wheels 14, 16, in the exemplary embodiment of the cable laying apparatus 10, the point of contact 61 is angularly positioned within a range of zero to twenty degrees down from a horizontal extension of the axes 17, 19. Specifically, as shown in FIGS. 3 and 8a, the turf slicing wheels 14, 16, of the exemplary embodiment of the apparatus 10, are operatively attached to the mounting yoke 12, by a pair of bearings located within bearing hubs 13, 15 attached to the turf slicing wheels 14, 16. In the exemplary embodiment, the contact point 61 is horizontally disposed slightly below the outer periphery of the hubs 13, 15, which results in the point of contact 61 being vertically positioned substantially horizontally level with the axes 17, 19, and being positioned substantially at ground level G when the apparatus is slicing the turf, such that substantially the entire radius R of the turf slicing wheels 14, 16 is disposed below the ground level G, during operation of the cable laying apparatus 10, as illustrated in FIG. 8a.

[0066] In FIG. 8a, the turf slicing wheels 14, 16 are illustrated with a scale diameter of 14", and a diameter of the hubs (13, 15) of 3". When the turf slicing wheels 14, 16 are lowered into the ground to a point where the hubs 13, 15 are positioned just above the surface G of the ground, an embodiment of the invention having 14" diameter turf slicing wheels (14, 16) and 3" diameter hubs 13, 15, will extend into the ground to a depth D substantially equal to the radius R of the wheels 14, 16 minus the radius r of the hubs 13, 15, such that the resultant depth D of the slice in the turf will have a depth of approximately 5 1/2" below the surface of the ground G. When operated in this manner, the point of contact 61 of a 14" diameter turf slicing wheel, with a 3" diameter hub, will be located at an angle 21 of approximately 15° downward from a horizontal extension of the axes 17, 19, when the contact point 61 is positioned at the ground level G.

[0067] For purposes of comparison, the diameter of the Coulter A in the prior art seed-planting apparatus, shown in FIG. 7a, and the diameter of the angularly displaced turf slicing wheels 14, 16, of the exemplary embodiment of the invention shown in FIG. 8a are illustrated to the same scale. By comparison of FIG. 7a and 8a, it will be readily understood that the positioning of the contact point 61 of the present invention is substantially different than the position of the contact point C in seed-planting apparatuses. In the present invention, the depth D of the slice in the turf is substantially equal to the radius R of the turf slicing wheels 14, 16. In the exemplary embodiment of the underground cable laying apparatus 10, having the turf slicing wheels 14, 16 attached to the mounting yoke 12 by hubs 13, 15 having a 3" diameter, the depth D is reduced only by the relatively small radius r of the hubs 13, 15. In other embodiments of the invention, having smaller hubs, or essentially hub-less attachments of the turf slicing wheels to a mounting yoke, the turf slicing wheels may be lowered even further into the ground, to a point where the contact point 61 between the turf slicing wheels 14, 16 lies virtually at ground level G, with the resultant depth D of the slice in the turf having a depth virtually identical to the radius R of the turf slicing wheels 14, 16.

[0068] By way of comparison, as shown in FIG. 7a, and as previously discussed in the Background section above, the point of contact C in a seed-planting apparatus is typically positioned much farther below the axis B of the a coulter of the seed-planting apparatus, such that the point of contact C is typically located at a much larger angle E down from the horizontal extension of the axis B than is utilized in practicing the present invention. For example, as previously stated above, seed-planting apparatuses typically position the point of contact C at an angle E of 35° to 55° below the horizontal extension of the axis B, such that, when the seed-planting apparatus is operated with the point of contact C located substantially at ground level, the depth D of the furrow formed will be substantially less then the radius R of the coulter of the seed-planting apparatus.

[0069] As shown in FIG. 8b, by virtue of the pair of turf slicing wheels 14, 16, of the exemplary embodiment 10, being angularly displaced relative to one another along a vertical axis of the mounting yoke, in the manner illustrated in FIGS. 3 and 8b, the forward contact area 62 extends substantially downward from the point of contact 61, with the outer peripheries of the turf slicing wheels 14, 16 diverging below the forward contact area 62, in such a manner that the slit in the turf has a defined horizontally extending bottom width W thereof, as shown in FIGS. 8b and 8c. The shape of the slit in the turf, created by the turf slicing wheels 14, 16 of the exemplary embodiment of the apparatus 10, according to the invention, thus has a substantially different shape than the V-shaped furrow of the type created by seed-planting equipment, as illustrated in FIG. 7b. For purposes of illustration, FIGS. 7b, 8b and 8c are all shown in the same relative scale, with the depth D of the slit shown in 8b and 8c as created according to the present invention being illustrated at a relative depth D of approximately 6" below the surface of the ground G and the depth D of the V-shaped furrow of FIG. 7b being illustrated at a representative depth of approximately 3".

[0070] A comparison of FIGS. 8b and 8c with FIG. 7b also serves to illustrate other differences between the slit and turf created through practice of the present invention, as compared to the V-shaped furrow created in non-turf bearing soil of the type created by typical seed-planting equipment. As shown in FIG. 7b, seed planting apparatuses typically remove soil from the V-shaped furrow and deposit it on top of the ground G in the process of forming the V-shaped furrow. In contrast, in the slit in the turf created through practice of the present invention, the turf is neatly sliced by the forward contact area 62 of the turf slicing wheels 14, 16, and the turf is separated far enough, as the turf slicing wheels 14, 16 move forward, to allow the cable 68 to be inserted aft
of the turf slicing wheels 14, 16. Because of the resilient nature of the turf, soil from the slit in the turf is not brought up and deposited on top of the ground, as is the case in seed-planting apparatuses. The soil is held in place by the turf and its roots, substantially within the slice in the turf. As illustrated in FIG. 8b, as the turf cutting wheels 14, 16 move through the soil, the initial slit is widened by the angled position of the turf slicing wheels 14, 16, and although the turf tends to rise upward somewhat behind the hubs 13, 15, soil is not removed from the slit and deposited on top of the ground.

[0071] In practicing the invention, it is preferable that the turf be well watered, to enhance its capability to be spread apart, without having dry loose dirt particles brought up onto the surface of the ground, and also to be more readily compacted over the cable, after the cable has been deposited in the bottom of the slice in the turf.

[0072] As may be seen from the rear isometric view of FIG. 4, the cable feed guide wheel 46 is positioned to dispense the cable to be laid in the center of the slit in the turf created by turf slicing wheels 14, 16, prior to the application of the closing force on the slit by turf closing wheels 22, 24.

[0073] In operation, the apparatus 10 is lowered by the vehicle so that the contact area 62 of the turf slicing wheels contacts the upper surface 64 of the turf with the contact point 61 located substantially at the surface G of the ground. As the vehicle travels across the turf, rotation of the turf slicing wheels 14, 16 creates the slit in the turf that preferably opens both horizontally and vertically to receive the cable to be laid therein. Since the turf closure wheels 22, 24 are displaced horizontally from one another by an amount greater than the maximum slit width, the wheels 22, 24 ride on the outside of the slit and provide a downward and inward closure force to effectuate a closure of the slit once the cable has been laid therein. The amount of force applied on the sides of the slit is dependent upon the setting of the spring force of the turf follower spring 52 as discussed above. Also, due to the close proximity of the turf closure wheels 22, 24 to the rearward edge of the turf slicing wheels 14, 16, closure of the slit into which the cable has been laid occurs in very close proximity to the point where the cable leaves the cable feed guide wheel. In this way, the proper positioning of the cable within the slit is ensured. With prior trencher systems, coils of the cable which may allow the cable to rise above the bottom of the trench before the soil is placed back in the trench, resulting in areas where the cable is shallower than in others, which may result in uncovering of the cable and forming a hazardous condition.

[0074] As discussed briefly above, to ensure that the cable is properly positioned within the slit in the turf, in the exemplary embodiment of the cable laying apparatus 10, a cable feed guide wheel 56 is used. However, one skilled in the art will recognize that a roller or other guide mechanism may be used at this location such as the alternate embodiment discussed below in relation to FIGS. 9-15, to provide proper placement and smooth transitioning of the cable from the cable feed tube to its position in the bottom of the slit.

[0075] In an embodiment that utilizes a cable feed guide wheel 26, such as that illustrated in FIG. 6, the provision of a guide wheel cleaning mechanism may be desired. As introduced above, this cleaning mechanism may include a cable groove cleaning rod 50 that rides in the groove 48 of the cable feed guide wheel 46. As the wheel rotates while dispensing the cable 68 any dirt or other debris that may accumulate within groove 48 will be displaced by the cleaning rod 50. Similarly, the cable feed guide wheel housing 70 may include wheel edge scrapers 72, 74 that clean the sides of the wheel 46 and prevent the accumulation of soil or other debris, which may affect the ability of the wheel 46 to rotate.

[0076] In practicing the invention, a cable feed guide may take a variety of forms other than the grooved cable guide wheel 46 described above. For example, FIG. 9 illustrates a cable guide wheel or roller 80 which does not include the groove 48 of the embodiment of the cable feed guide wheel 46. Generally speaking, so long as the cable feed guide element used in practicing the invention presents a non-convex, i.e. flat or downwardly opening concave surface, acting against the upper surface of the cable 68, the cable feed guide will serve to hold the cable 68 in proper position in the bottom of the slit prior to the slit being closed by the turf closing wheels 24, 26.

[0077] FIGS. 10 and 11 illustrate alternate embodiments of a cable guide wheel or roller (46, 80) formed from a material, or configured in a manner that the surface of the wheel or roller may deform about the upper surface of the cable 68. Cable guide wheels or rollers formed from a resilient material provide an additional advantage in that they tend to inherently shed dirt from the outside surfaces thereof, as the wheel or roller flexes.

[0078] FIGS. 12 and 13 illustrate an alternate embodiment of the invention, in which the feed tube 36 includes a static cable feed guide 82, attached to the cable feed guide tube outlet 42, for directing the cable 68 in a horizontal direction for discharge into the slit in the turf. As best seen in FIG. 13, the static cable feed guide 82 defines a downwardly opening substantially concave surface 84 adapted for contacting the upper surface of the cable 68, with the downwardly opening concave surface 84 being configured to preclude having the cable 68 escape from the concave surface 84.

[0079] FIG. 14 illustrates an alternate embodiment of a cable feed guide 86, according to the invention, in the form of a flexible tubular shaped extension of the cable feed tube 36 having a bore therein, for directing the cable 68 into the slit in a horizontal direction, while the flexible tube extension 86 is being bent into a horizontal arc by contact between the bottom of the flexible tube extension and the bottom surface W of the slit in the turf. For such an embodiment, it is contemplated that the flexible tube extension may be made from a polymer or composite material, having sufficient bending stiffness to hold the cable 68 securely in the bottom of the slit in the turf.

[0080] FIG. 15 illustrates a variation of the alternate embodiment of the invention shown in FIG. 14, in which an underground laying apparatus 10, according to the invention, includes a flexible tube extension 88 which extends through the full length of the cable feed tube 36, and is secured therein by a projecting flange 90 at the inlet to the cable feed tube, with a portion of the flexible tube 88 extending beyond the outlet end of the cable feed tube 36. With this embodiment of the invention, the flexible feed tube extension provides a continuous smooth surface from the
inlet to the outlet of the cable feed tube, in a form that may be readily replaced, as the flexible tube extension becomes worn. Alternatively, a selection of different flexible tube extensions, each having, respectively, bores thereof sized and/or appropriately shaped to accommodate various sizes and types of cable, wire, tubing, etc. to be installed with the cable laying machine may be provided, to tailor the configuration of the feed tube and cable feed guide to the particular type of cable and/or tube being installed.

[0081] FIG. 16 illustrates an alternate embodiment of the closure wheels 22, 24 of the exemplary embodiment of the underground cable laying apparatus 10. In the alternate embodiment of the turf closing wheels 22, 24, shown in FIG. 16, the outer periphery of the turf closing wheels 24, 26 is configured to form a wide, flat area of contact with the turf, which may be more advantageous than the more rounded shape of the embodiment of the turf closing wheels 22, 24 shown in FIG. 4, for certain conditions of the turf, such as when the turf is relatively wet or somewhat sparse. In other embodiments of the invention, the turf closing wheels may have yet other configurations. Turf closing structures, having appropriate configurations other than wheels may also be used in practicing the invention, in combination with other aspects of the invention.

[0082] The underground cable laying apparatus of the present invention provides significant advantage through the use of the turf slicing wheels, particularly in installation locations where other installed underground systems may be in place, and where a visible scar in the turf resulting from the cable laying operation is not desired. In the first instance, the apparatus of the present invention provides a significant advantage through the use of the rotating turf slicing wheels for providing the slit in the turf into which the cable is to be laid. Since the turf slicing wheels rotate, there is a significantly reduced likelihood of damage to other installed underground systems as results from typical trenchers. Specifically, the rotating turf slicing wheels will not snag and pull the other underground systems which it encounters, and instead merely rolls over them while leaving them in place. This non-damaging contact with previously installed underground systems is aided by the angular relationship between the two turf slicing wheels. That is, the relative angular displacement of the turf slicing wheels forms a contact portion 62 that slices the top layer of the turf, but then separate from one another at all other locations. As a result, contact with previously installed underground systems often occurs at a position where the turf slicing wheels 14, 16 are separated from one another; but are still in close proximity. As a result, the contact force is dispersed at the two contact points with each of the individual turf slicing wheels. Since these wheels are most likely still in close proximity, the contact force is not sufficient to damage the exterior surface of the previously installed underground system.

[0083] In the second instance, unlike blade type systems that gouge a slit into the turf, and trencher systems that completely remove the soil to form a trench, the underground cable laying apparatus of the present invention merely opens a slit in the turf, which is quickly reclosed once the cable has been placed therein. The angular placement of the turf slicing wheels ensures a narrow slit is initiated in the turf, is slightly widened to allow placement of the cable therein, and then is immediately reclosed by providing angular downward and inward force on the sides of the slit opened by the turf slicing wheels. As a result, it is nearly impossible to observe where the slit was opened in the turf once the cable has been laid therein. This is especially true when the turf is moist, or has been recently watered.

[0084] Experience has shown that the present invention may be practiced in a wide variety of soil types and turf conditions. It is preferred, when practicing the invention, that the turf be generally well watered, so that the soil is moist down to the depth D of the slit below the surface of the ground G. Accordingly, it may be desirable in practicing the invention, to water the turf prior to installing the cable therein.

[0085] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0086] The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) is to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to," unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0087] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. An underground cable laying apparatus, comprising:
   a mounting yoke;
   a pair of angularly displaced turf slicing wheels rotatably coupled to the mounting yoke, the turf slicing wheels defining a forward contact area therebetween; and
a cable guide tube positioned aft of the forward contact area of the turf slicing wheels, the cable guide tube having a cable inlet and a cable outlet.

2. The underground cable laying apparatus of claim 1, wherein, each of the angularly displaced turf slicing wheels defines a radius and an outer periphery thereof, and is mounted for rotation about a respective turf slicing wheel axis directed such that, when viewed from either side of the apparatus, the outer peripheries of the turf slicing wheels are substantially superimposed upon one another vertically and horizontally, with the peripheries coming together at a point of contact in the forward contact zone and disposed substantially horizontally forward of the axes of the turf slicing wheels.

3. The underground cable laying apparatus of claim 2, wherein, the point of contact is angularly positioned within a range of zero to 20 degrees down from a horizontal extension of the axes.

4. The underground cable laying apparatus of claim 2, wherein, the point of contact is vertically positioned substantially horizontally level with the axes, and substantially at ground level when the apparatus is slicing the turf, such that substantially the entire radius of the turf slicing wheels is disposed below ground level in operation.

5. The underground cable laying apparatus of claim 4, wherein, the pair of turf slicing wheels are angularly displaced relative to one another along a vertical axis of the mounting yoke in such a manner that the forward contact area is disposed substantially below the point of contact, and outer peripheries of the turf slicing wheels diverge below the forward contact area, in such a manner that the slit in the turf has a defined horizontally extending bottom width thereof, rather than being substantially V-shaped and terminating in a vertex of the V-shape at the bottom of the slit.

6. The underground cable laying apparatus of claim 1, wherein the pair of turf slicing wheels are angularly displaced relative to one another along both a horizontal and a vertical axis of the mounting yoke.

7. The underground cable laying apparatus of claim 1, further comprising:

a turf closure housing pivotally coupled relative to the mounting yoke; and

a pair of angularly positioned turf closing wheels rotatably coupled to the turf closure housing.

8. The underground cable laying apparatus of claim 7, further comprising a pair of closure assembly mounting arms fixably coupled to the mounting yoke, and wherein the turf closure housing is pivotally coupled to the closure assembly mounting arms.

9. The underground cable laying apparatus of claim 7, further comprising, a turf follower spring coupled between the mounting yoke and the turf closure housing.

10. The underground cable laying apparatus of claim 9, further comprising, a spring tension nut positioned to vary a bias force supplied by the turf follower spring.

11. The underground cable laying apparatus of claim 1, further comprising, a feed tube support extension member coupled to the cable guide tube in proximity to the cable outlet.

12. The underground cable laying apparatus of claim 1, further comprising, a cable guide coupled to the cable feed tube and displaced from the cable inlet to aid in guiding cable into the cable inlet.

13. The underground cable laying apparatus of claim 1, wherein, the cable guide tube is curved from the cable inlet to the cable outlet.

14. The underground cable laying apparatus of claim 13, wherein, the outlet of the cable guide tube is oriented to discharge the cable substantially horizontally.

15. The underground cable laying apparatus of claim 1, wherein the mounting yoke includes at least one mounting receptacle.

16. An apparatus for laying cable under turf without leaving a visibly obvious scar in the turf, comprising:

a mounting yoke having at least one mounting receptacle defined therein;

a pair of turf slicing wheels rotatably mounted on the mounting yoke, the turf slicing wheels being positioned in a diverging relationship to one another such that a slit is opened in the turf when the pair of turf slicing wheels is pulled therethrough; and

a cable feed tube positioned between the pair of turf slicing wheels and terminating in a cable outlet position to guide the cable into the slit opened by the pair of turf slicing wheels.

17. The apparatus of claim 16, further comprising a turf closure assembly operably coupled to the mounting yoke and positioned relative to the pair of turf slicing wheels to close the slit in the turf opened thereby anterior of the cable outlet.

18. The apparatus of claim 17, wherein the turf closure assembly comprises a pair of turf closing wheels angularly positioned relative to one another and laterally displaced from one another a distance greater than a lateral spacing at a trailing edge of the pair of turf slicing wheels.

19. The apparatus of claim 16, further comprising a cable feed guide mechanism positioned anterior and vertically downward of the cable outlet relative to a surface of the turf to position the cable within the slit in the turf and to protect an outer surface of the cable from scraping.

20. A method of laying cable under a lawn, comprising the steps of:

lowering a pair of turf slicing wheels into the lawn;

moving the pair of turf slicing wheels through the lawn to open a slit therein;

guiding cable into the slit in the lawn; and

closing the slit after the cable has been positioned therein.

21. The method of claim 20, wherein the step of moving the pair of turf slicing wheels through the lawn comprises the step of moving the pair of turf slicing wheels through the lawn such that the pair of turf slicing wheels rotate.

22. The method of claim 20, further comprising the step of watering the lawn prior to the steps of lowering, moving, guiding, and closing.

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