United States Patent

[11] 3,598,027

[72] Inventor George W. Swisher, Jr.
Oklahoma City, Okla.
[21] Appl. No. 796,853
[22] Filed Feb. 5, 1969
[45] Patented Aug. 10, 1971
[73] Assignee CMI Corporation
Oklahoma City, Okla.

[54] METHOD OF ROAD CONSTRUCTION

13 Claims, 9 Drawing Figs.

[52] U.S. Cl. 94/22, 94/40
[51] Int. Cl. E01c 21/00
[50] Field of Search 94/40, 39.5, 39.51, 39.511, 39.22; 37/108

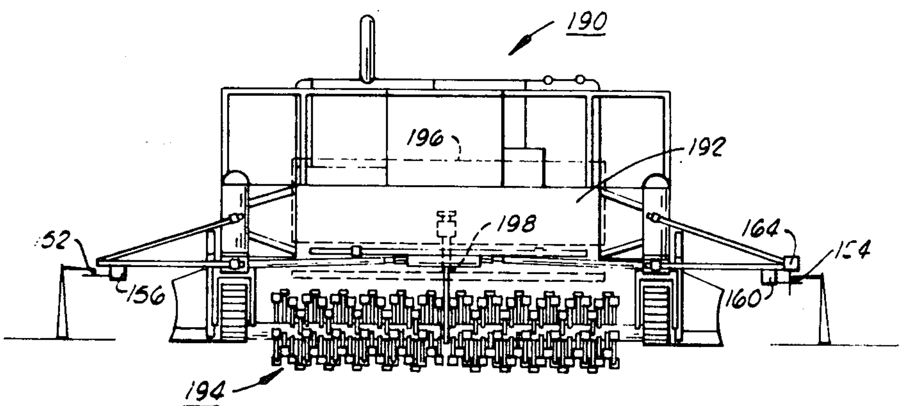
[56] References Cited

UNITED STATES PATENTS

1,269,098	6/1918	Latta	94/39
1,632,969	6/1927	Horner	94/39
1,953,890	4/1934	Allen	94/39
2,128,273	8/1938	Stevens	280/6
2,201,493	5/1940	Jorgensen	94/40
2,902,908	9/1959	Schiavi	94/39
3,224,347	12/1965	Seaman	94/40
3,418,901	12/1968	Hanson	94/39
3,423,859	1/1969	Swisher	37/108
3,435,546	4/1969	Iverson	37/108
3,452,461	7/1969	Hanson	94/40 X

Primary Examiner—Nile C. Byers, Jr.
Attorney—Dunlap, Laney, Hessin and Dougherty

ABSTRACT: A method of stabilization of earth material to a controlled depth to form a roadway base material or subgrade, the method consisting of cutting and comminuting native or prepared earth material to an automatically controlled depth whereupon cut material is spread to an automatically controlled thickness above the controlled depth line to form an even layer of the comminuted material for utilization as a roadway base capable of receiving and supporting paving material thereupon. Depending upon the suitability of the earth material for base purposes, additional steps may be taken to add specified liquid or dry materials to the comminuted earth material to adjust the plasticity index to a proper value for utilization as a paving material support substance.



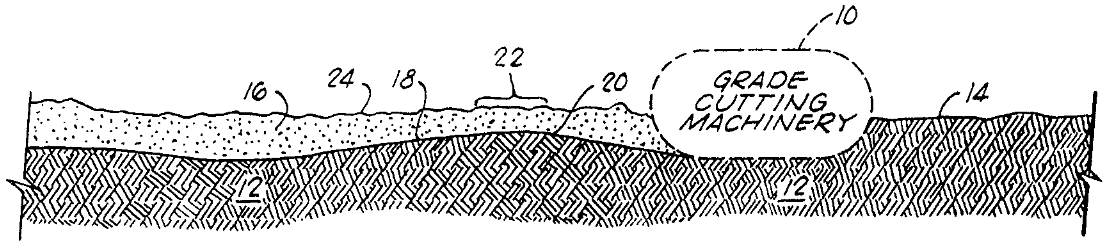


Fig-1

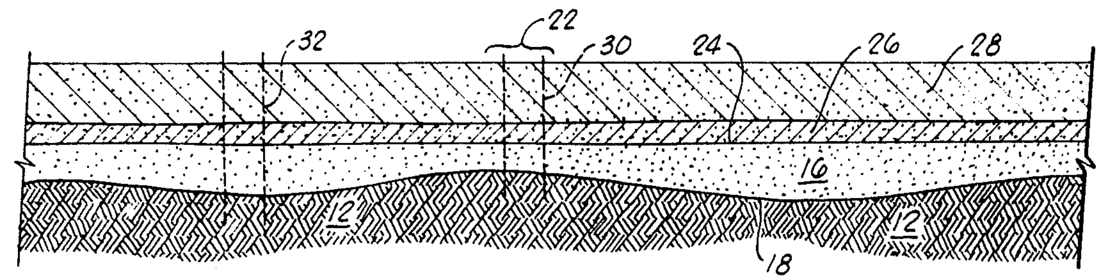


Fig-2

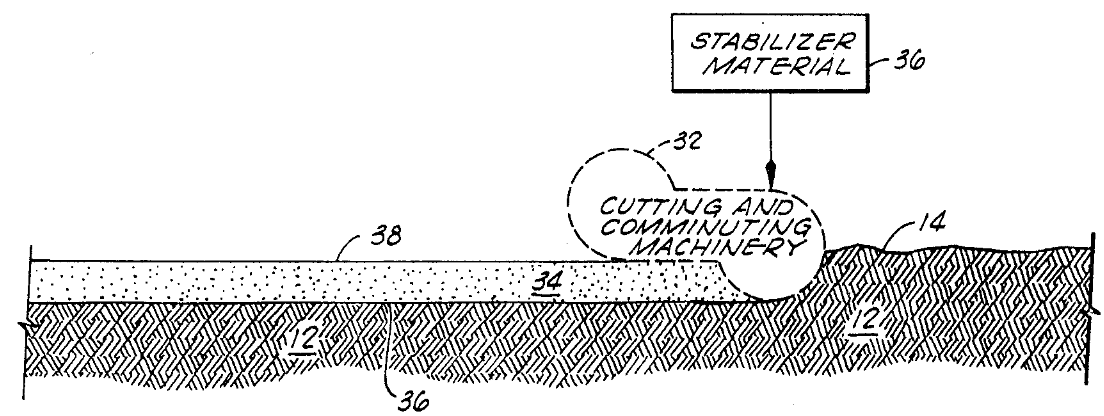


Fig-3

INVENTORS
GEORGE W. SWISHER JR.

BY
Dunlap, Laney, Hessin & Dougherty
ATTORNEYS

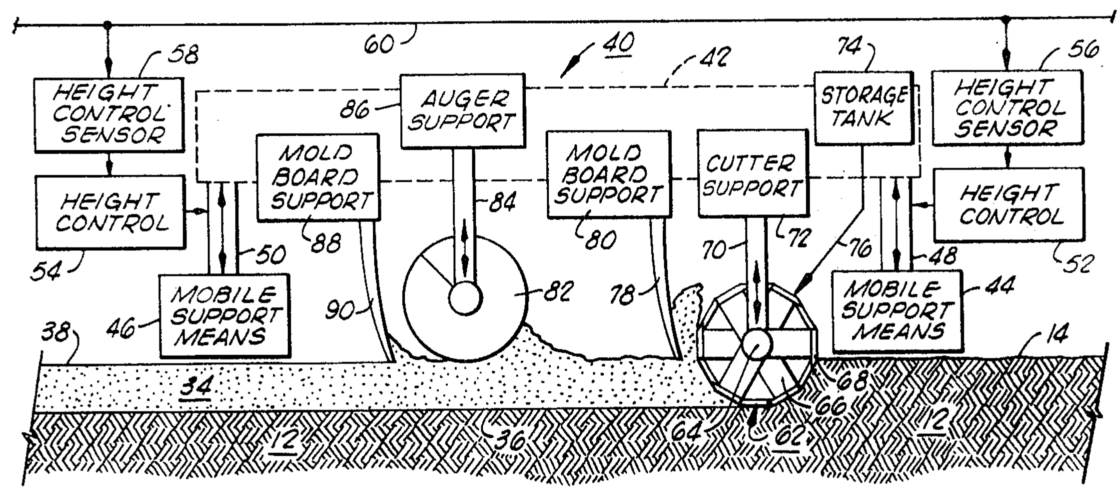


Fig. 4

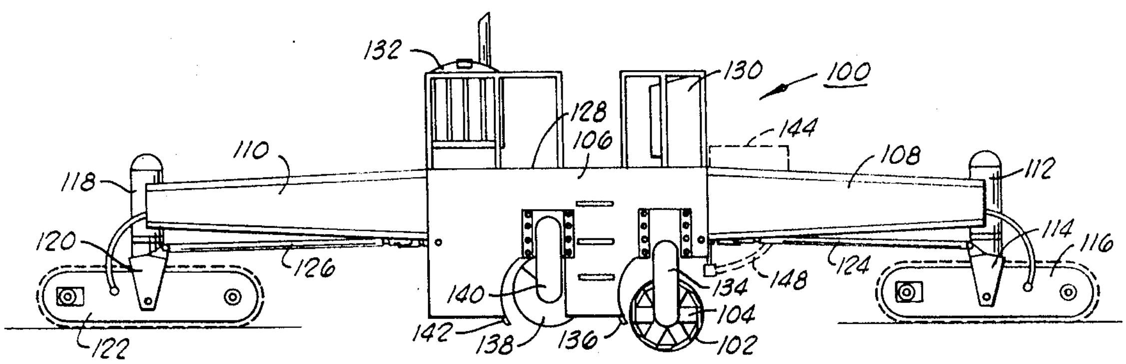


Fig. 5

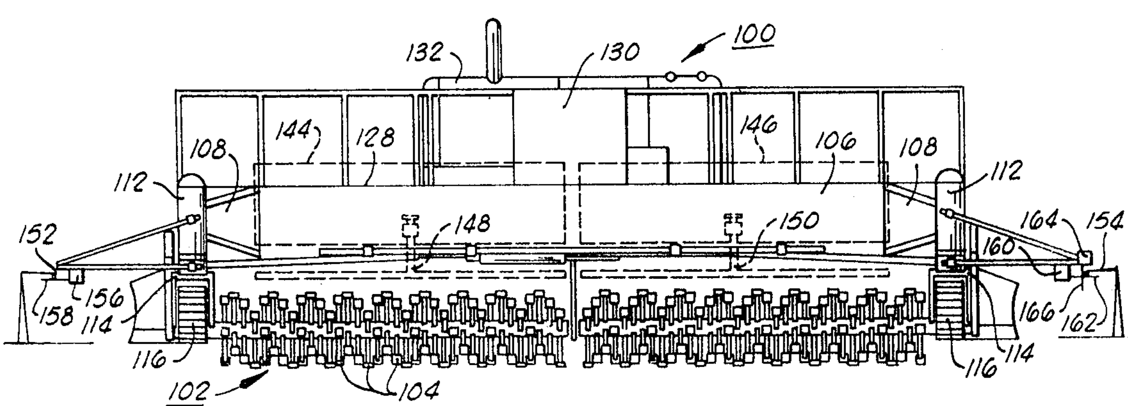


Fig. 6

INVENTORS
GEORGE W. SWISHER JR.

BY
Dunlap, Laney, Hessin & Dougherty
ATTORNEYS

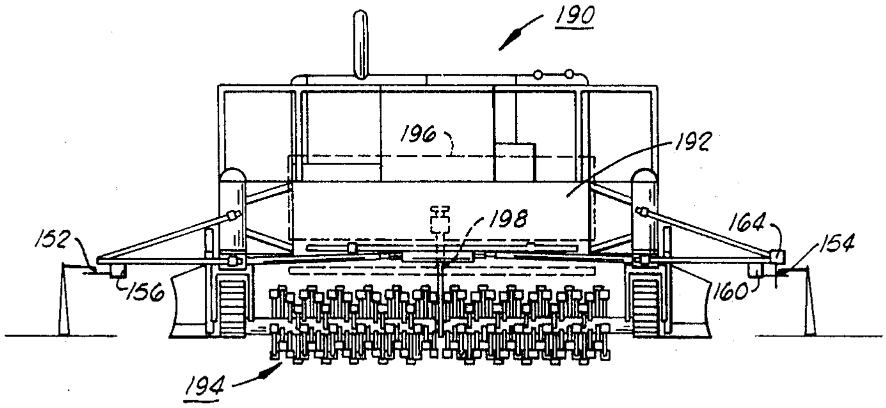


Fig-9

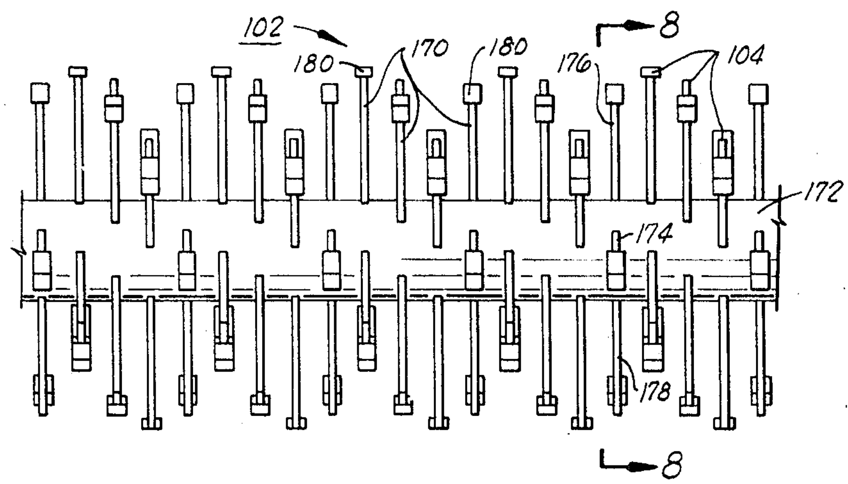


Fig-7

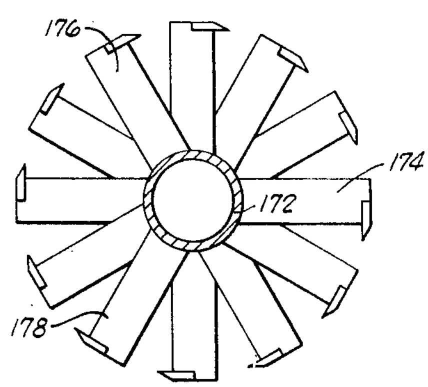


Fig-8

INVENTORS
GEORGE W. SWISHER JR.

BY
Dunlap, Laney, Hessin & Dougherty
ATTORNEYS

METHOD OF ROAD CONSTRUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to a method of roadway construction and, more particularly, but not by way of limitation, it relates to an improved method of forming a roadway base to a controlled depth for deposition of earth material cut and processed in situ.

2. Description of the Prior Art

The prior art includes various teachings directed to utilization of native or other earth material in forming support structure for overlay of roadway surfaces. Prior attempts at "in place" stabilization were characterized by an inability to maintain reliably a specified depth or base line and, therefore, a proper thickness of the stabilized base layer; and, deleterious effects to finished roadways containing such base layer have necessitated outlawing of such practices in many states. That is, earth material may have been cut, ground and whatever for placement as base material and then leveled off to a neat line to form the base layer; however, the prior methods allowed no way whereby it could be ascertained that the base layer was uniform in thickness, i.e. the roadway bottom or base line was not cut to a controlled level or depth.

SUMMARY OF THE INVENTION

The present invention contemplates a method of road construction utilizing native or prepared earth material for base material wherein the earth material is cut, comminuted and layered automatically at a controlled depth and having a controlled thickness. In a more limited aspect, the invention consists of cutting the earth material to a predetermined base line as automatically controlled from a preselected external reference line, and comminuting the earth material to a desired consistency or maximum particle size for placement on the cut roadway above the base line to a desired thickness also controlled from the reference line. It is further contemplated to inject stabilizing additives, either liquid or dry in form, to the cut earth material for mixture therewith to adjust the stabilization properties such that the stabilized base is optimally processed to receive additional roadway material for support thereon.

Therefore, it is an object of the present invention to provide a method for building roadways from the base structure upward while utilizing native earth materials for stabilization.

It is also an object of the invention to provide a method of forming roadway base structure from earth material wherein each interface of the base structure is automatically formed at a controlled depth.

It is a further object of the invention to enable utilization of native earth material in forming reliable, controlled depth roadway base where the physical characteristics of the native earth material will permit.

Finally, it is an object of the present invention to provide a method of roadway construction which enables great economy with little or no reduction in strength and reliability of roadways.

Other objects and advantages of the invention will be evident from the following detailed description when read in conjunction with the accompanying drawings which illustrate the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts a section of earth surface with a layer of cut native earth material as might be formed by conventional roadbuilding machinery utilized for grade cutting;

FIG. 2 depicts a section of paved roadway formed along the same earth section as shown in FIG. 1;

FIG. 3 depicts a section of earth surface having a cut and comminuted native material base layer formed thereon to a controlled depth and thickness in accordance with the present invention;

FIG. 4 is a partial block diagram of apparatus which may be utilized in carrying out controlled depth stabilization in situ in accordance with the present invention;

FIG. 5 is a side elevation of one form of apparatus which may be utilized in carrying out the method of the invention;

FIG. 6 is a front view of the apparatus shown in FIG. 5;

FIG. 7 is an enlarged, front elevation of a cutter as may be utilized in the apparatus of FIGS. 5 and 6;

FIG. 8 is a section of the cutter as taken along lines 8–8 of FIG. 7; and

FIG. 9 is a front view of roadbuilding apparatus similar to that of FIGS. 5 and 6 but being adapted for single-land usage with increased cutter speed.

DETAILED DESCRIPTION OF THE INVENTION

The method of the present invention enables construction of roadway utilizing native or prepared earth materials in situ as base support layer, and the method brings reliability to such practice through the employ of automated profile roadbuilding techniques. That is, recent advances in automated profile roadbuilding is based upon the premise that you build a roadway from the bottom up and not from the top down as has been done since early days of road construction with less than desirable results. Such latter day techniques have been brought about primarily through the capabilities of recent construction equipment innovations as best exemplified by the teachings of U.S. Pat. application Ser. No. 446,239 entitled "Road Construction Method and Apparatus" and filed on Apr. 7, 1965 in the name of George W. Swisher et al., now U.S. Pat. No. 3,423,859, and copending U.S. Pat. application Ser. No. 749,823 entitled "Control Systems for Road Construction Machinery" filed on Aug. 2, 1968 in the name of George W. Swisher, Jr., et al.

The prior attempts at utilization of native earth material for placement in situ as roadway base layer was generally unreliable due to an inability to maintain a uniform depth after compaction of the base layer along a right-of-way. FIG. 1 depicts such a prior attempt to rearrange earth material in situ. Grade-cutting machinery **10**, such as conventional bulldozers, motor-graders, and various other cutting and loading machinery, might be utilized in one or more units to remove native earth material from the earth **12** having a surface **14**. The grade-cutting machinery **10** would attempt to move a certain top depth of the earth **12** to redeposit loosened or broken up earth material **16** along the right-of-way. While the grade-cutting machinery **10** could continually cut down to a base line **18**, there has been no known practice whereby the base line **18** could be maintained uniformly level to the roadway neat line such that it would also insure uniformity of base layer **16** when compacted thereon. For example then, when the base line **18** experiences an undulation peak **20** the base layer **16** in the area **22** would, of necessity, constitute a thinner layer since the upper surface **24** of the base layer **16** will be compacted and smoothed to the roadway neat line.

FIG. 2 shows the manner in which a faulty section of finished roadway might result from the attempt at in place stabilization or utilization of native earth material as depicted in FIG. 1. The base layer **16** will have been smoothed and compacted such that upper surface **24** will equal the grade neat line; thereafter, a suitable form of base material **26** might be deposited in uniform layer and/or a paving material slab **28** will next be supported to provide the roadway surface. The employ of base **26**, e.g. bituminous aggregate or other well-known base material, as well as the thicknesses of base **26** and paving material **28** will vary with the exigencies of different applications as well as requirements of building specifications in the locale.

In any event, core samples taken at spaced intervals along the roadway as depicted in FIG. 2 will show variations in the base layer **16**, some of which can be extremely detrimental to roadwear and the ability to withstand normal temperature changes. A core sample taken at area **22**, shown by dash lines **30**, will show that the base layer **16** is of much less thickness than the same base layer **16** as sampled by a core taken along dash lines **32**.

As shown in FIG. 3, the method of the present invention enables utilization of earth material as a stable base layer which can be uniformly extruded along a right-of-way having an automatically controlled depth. Thus, a suitable form of cutting and comminuting machinery **32** is moved along a surface **14** of earth **12** to cut and comminute the native earth material for deposition in a base layer **34** of uniform thickness and density. The stabilization properties of the native earth material may be adjusted to provide best function as a pavement base layer. Thus, it may be desirable to adjust the plasticity index, i.e. the difference in moisture content of soil between the liquid and plastic limits as expressed in percentage, so that the base capabilities may be altered to an optimum value. A suitable stabilizer material **35**, e.g. lime, water, oil, and other well-known additives, may be interjected into cutting and comminuting machinery **32** for thorough mixture throughout the native earth material prior to its being deposited as uniformly thick base layer **34**.

Automated profile control is maintained over the cutting and comminuting machinery **32** such that it cuts down to a uniform base line **36** which is continually maintained at a uniform distance from some external reference, thus, controlled depth as will be further described below. Similarly, the cutting and comminuting machinery **32** has the capability of leaving the base surface **38** at a uniform distance above the base line **36**, it too being controlled from the external reference source. Such automatic profile control enables the guidance and cutting depth control of the cutting and comminuting machinery **32** to deposit base layer **34** of native earth material along the right-of-way. Such automatic profile control is the particular subject matter of the aforementioned Pat. applications, U.S. Ser. Nos. 446,239 (now U.S. Pat. No. 3,423,859) and 749,823. While description is directed more to the techniques of utilizing the native earth material, it should be understood that the present method is equally applicable to controlled depth cutting with preparation of imported or prepared base material. The use of native material is desirable for obvious reasons, but not always possible for obtaining required results.

Referring now to FIG. 4, the apparatus **40** exemplifies a form of device or mechanical structure which is suitable for carrying out the method of the invention. The apparatus **40** may consist of a frame **42**, of suitable shape as necessitated by design requirements, which is movably supported on forward mobile support means **44** and rearward mobile support means **46**. The respective support means **44** and **46** are connected via extendable support members **48** and **50**, respectively, to the frame **42**, and each of extendable support members **48** and **50** is operative under the control of respective height controls **52** and **54**. Height controls **52** and **54** are individually controlled from respective height sensors **56** and **58** which derive height or level indication from an external reference, in this case, a stringline **60**. Level sensing of stringline **60** for input to control the respective height control sensors **56** and **58** may be by various well-known means such as are described in the aforementioned U.S. Pat. applications Ser. Nos. 446,239 and 749,823; and such controls are the particular subject matter of a U.S. Pat. application Ser. No. 683,256 entitled "Line Tracer Control Device" filed Nov. 15, 1967 in the name of Steele et al.

The frame **42** may then carry a succession of operating elements such as a rotary cutter **62**. The rotary cutter **62** may consist of a rotating shaft **64** carrying a plurality of cutter arms **66**, each of which supports a cutter tooth **68** on the end thereof. The rotary cutter **62** is supported from a support member **70** which is adjustably connected to a cutter support **72** supported by the main frame **42**. A suitable reservoir or storage tank may be secured to the main frame **42** for the purpose of holding stabilizer material for injection via a suitable input conduit **76** into the general area of comminution about rotary cutter **62**. A mold board **78** is suspended from a mold board support **80** which is adjustably affixed to the main frame **42**. Similarly, a rotary distributing auger **82** is supported from an elongatable support member **84** which is suspended from frame **42** by means of an auger support **86**, and a rear moldboard support **88** extends rear moldboard **90** downward to the rear of rotary auger **82**.

The frame **42** has its level adjusted in response to height control sensors **56** and **58** which control the operations of height controls **52** and **54** to vary the elongation of the respective support members **48** and **50**. Each of the rotary cutters **62**, moldboard **78**, auger **82** and rear moldboard **90** is individually adjustable as to depth of operation below frame **40** by the adjustment of their respective cutter support **72**, moldboard support **80**, auger support **86** and rear moldboard support **88**. For an initial setting of the relative displacement of the operating elements, i.e. the setting of rotary cutter **62** at a preset depth and with moldboard **78**, rotary auger **82** and moldboard **90** relatively displaced at a higher level, the frame **42** may be moved along the right-of-way with support members **44** and **48** set at a level which is determined in relation to the stringline **60**. Continual adjustment of the level of frame **42** relative to stringline **60** also serves to adjust the depth of cutting at base line **36** as well as the base surface **38** which is displaced a predetermined distance thereabove.

One form of automatic profile machinery which is suitable for employ in carrying out a stabilization in situ method as disclosed herein is shown in FIG. 5. This apparatus is similar to that disclosed in the aforementioned U.S. Pat. application Ser. No. 446,239 with the exception that the rotary cutter is altered as will be described below. The construction machine **100** is essentially a dual lane automatic grade-cutting machinery as disclosed in the prior application; however, alteration of rotary cutter **102** such that it includes an increased number of individual cutter arms **104**, each being somewhat longer than the conventional cutter elements, will enable function in accordance with the method of the present invention. Construction machinery **100** consists of a main frame **106** which is supported by a pair of forward support legs **108** and rearward support legs **110** disposed in quadrature array. The forward support legs **108** are secured to respective forward vertical supports **112** which, in turn, are connected to yoke members **114** which are attached for support above mobile track units **116**. The rear support legs **110** connect to respective rear vertical supports **118** which extend from yokes **120** and rear mobile track units **122**. Forward and rearward steering is effected through tension bars **124** and **126** in a manner which is disclosed at length in the aforementioned U.S. Pat. application Ser. No. 446,239.

The top surface of main frame **106** serves as an operating platform **128** and an operator's console **130** is disposed at the forward edge thereof while a central power source **132** is supported at the rear. The rotary cutter **102** is supported from cutter support **134** which is vertically movably supported beneath main frame **106**. While various power input forms may be employed to supply drive to the rotary cutter **102**, a suitable form of hydraulic drive is employed which is capable of providing continuous control of rotary cutter **102** between 0 and 80 r.p.m. A moldboard **136** is also vertically adjustably supported beneath main frame **106** at a position just to the rear of rotary cutter **102** to provide both baffling and distribution function. A rotary auger **138** is supported from a support member **140** in vertically adjustably manner similar to that for rotary cutter **102**, and a similar hydraulic drive is also utilized to provide revolution control. A rear moldboard **142** is then vertically adjustably supported to the rear of auger **138**.

Stabilization material such as lime, water, or other stabilizing compounds may be retained in storage tanks **144** and **146** which are suitably secured across the front of the construction machine **100**. The storage tanks **144** and **146** may include respective control structures **148** and **150** for distributing the dried or liquid-stabilizing material across the length of rotary cutter **102**. Respective left and right stringlines **152** and **154** are also shown as they may be contacted by the various steering and level control-sensing devices.

Thus, a right front level control **156** derives indications from a movable sensing arm **158** to control the vertical extension of vertical support member **112** relative to stringline **152**, the external reference source which in most cases would be constant to grade line of the right-of-way. A similar sensor (not specifically shown) would be disposed at the right rear to control vertical extension of vertical support member **118**. On the left side (right side of FIG. **6**), a control device **160** derives level control indications through position of sensing arm **162** as urged by stringline **154**, and steering sensing is derived from a control device **164** and sensing arm **166**. Similar level and steering control devices would be disposed adjacent the left rear of construction machine **100**. It should also be understood that the steering control sensing can be carried out on either side as a matter of choice. Such control sensing is described in greater detail in the aforementioned U.S. Pat. applications, Ser. Nos. 446,239 and 749,823.

Referring now to FIG. **7**, the rotary cutter **102** is shown in greater detail. The cutter **102** consists of a plurality of radially extending cutting members **104**. Each of cutter members **104** consists of a cutter arm **170** which is welded to and radially extending from a central shaft **172**. The cutter members **104** in one case may be arrayed in three intertwined helical flights, and that is the array as depicted in FIGS. **7** and **8**. Thus, noting FIG. **8**, the cutting members **104** are arrayed as three equally displaced helical flights as exemplified by particular cutter members **172**, **174** and **176** which are attached in coplanar affixture to the center shaft **172**. Each cutter arm **170** supports a cutter head **180** at its outward end, as has been found desirable in practice, the cutter heads **180** are so formed that they receive removable, hardened steel cutter teeth (not specifically shown) therein.

The rotary cutter **102** is primarily characterized by having an increased number of cutter members **104** disposed in greater density therealong so that cutter **102** has the capability of applying an extremely thorough chopping or cutting action to earth material as it moves along the right-of-way. In addition to the density of cutting members **104**, the rotary cutter **102** is also controllable over a wide range of rotary speeds to enable further adjustment as to the degree and uniformity of comminution of the native earth material. With standard rotary control systems as present in conventional forms of construction machine **100**, the operator may have the capability of controlling rotation of cutter **102** between 0 and 80 r.p.m. Still greater speeds approaching 120 r.p.m. are attainable when utilizing a single-lane type of machine as shown in FIG. **9**.

A construction machine **190**, another commercially available type of automatic grade control machine, is highly similar to the construction machine **100** of FIGS. **5** and **6** with the exception that it is built around a more narrow frame **192** which carries single-lane working or operating elements. In this case, a rotary cutter **194**, which is similar to rotary cutter **102** in tooth structure and density but about one-half as long, is employed at higher revolutional speeds. This is enabled by applying similar hydrostatic drive, but greater rotational speeds are realized since the two drive systems required by rotary cutter **102** (FIG. **6**) are both applied to control the single-lane rotary cutter **194**. It is capable of continuous control between 0 and 120 r.p.m.

Such speed capability and control enables a most thorough cutting and comminuting operation of earth material, and this also allows more thorough mixture of stabilizing material throughout the comminuted earth material prior to its deposition or extrusion as the base layer along the right-of-way. Stabilizing material may be retained in a suitable storage tank **196** which is affixed across the forward edge of frame **192** and which includes a suitable form of distribution structure **198** for leading stabilizing material down for controlled release into the comminution area about rotary cutter **194**.

In operation, and utilizing various of the apparatus capable of automatic profile control earth-working, or controlled depth cutting and comminution, the construction machinery is first set up relative to an external level reference such that the various operating elements are disposed at a preset depth. Thus, and referring to FIG. **4**, stringline **60** serves as the external reference line along a right-of-way and the cutter support **72** and support member **70** are adjusted so that rotary cutter **62** will cut to the elevation level of a predetermined base line **36** within the earth **12**. Similarly, the respective moldboard support **80**, auger support **86** and moldboard support **88** are preadjusted so that they will extend their respective operating elements to a preset level relative to reference or stringline **60**. The construction machine **40** can then proceed along a right-of-way cutting and comminuting the portion of earth material **12** above base line **36** for deposition in situ as a uniform base layer **34**. The base line **36** as well as the upper surface **38** of base layer **34** is automatically maintained at a controlled depth and thickness relative to the stringline **60**.

Depending upon the qualities of the native earth material, selected additives may be applied, e.g. through storage tanks **74** and injection line **76**, for the purpose of stabilizing the native earth material so that optimum base characteristics are achieved. For example, it may be desirable to add dry commercial lime at a certain rate to lower the plasticity index of the native earth material **12** to increase its ability to support a paving slab and the attendant loads thereon. A prior qualitative analysis of the native earth material **12** will indicate the type and degree of stabilization and stabilizer material which must be added. Amounts of stabilizer material injected through line **76** may be released by metering in accordance with stabilization requirements versus the speed of traverse of mobile support means **44** and **46** along the surface **14** of earth **12**.

While some native soils may require lime additive to bring about proper stabilization characteristics, it is contemplated that other applications may utilize oil or water or still other compounds as additives to the native earth material. Proper stabilization having been effected, the base layer **34** will be extruded out as a uniform layer with both base line **36** and surface **38** disposed at a constant distance from the external reference or stringline **60**. The base layer **34** can then be compacted by following equipment, the uniformity of base layer **34** being maintained due to the initial uniformity of deposition and particle size, whereupon it may be further prepared for additional base material and/or a topmost-paving material to provide the finished roadway.

In cases where native material is unsuitable for base purposes, such material will have to be imported. Thus, after cutting the roadway base line to a predetermined base or depth line relative to an external reference, imported material is deposited in the roadbed for controlled depth distribution. Native earth material must be completely removed above the certain prescribed depth line. There is still the assurance that the bottom of the roadway bed is true and uniform at a preset level relative to the grade line.

The controlling discloses a novel method of constructing roadways wherein native earth material is used to best advantage constant pavement base support. While the use of native soil is not novel in itself, the formation of a native earth material base layer with required stabilization as extruded or laid down in uniform thickness upon a base line which is true to the roadway grade line does constitute new and useful practice which effects great economy in the building of improved quality roads. Economies are enabled not only from savings in hauling, distributing and wastage of nonnative, prepared base materials, but also in job time and man hours per roadway unit distance.

Changes may be made in the combination and arrangement of steps and/or elements as heretofore set forth in the specification and shown in the drawings; it being understood that changes may be made in the embodiments disclosed without departing from the spirit and scope of the invention as it is defined in the following claims.

What I claim is:

1. A method for performing controlled depth stabilization of earth material in situ to form a constant profile layer along a predetermined roadway path comprising the steps of:
providing a reference line indicating the relative elevation level of said layer;
cutting and comminuting said earth material along said roadway path down to a first level which is disposed a predetermined constant distance from said reference line;
simultaneously spreading comminuted earth material approximately evenly on said roadway to a second level which is disposed a predetermined distance between said reference line and first level.

2. A method for performing controlled depth stabilization of native earth material as set forth in claim 1 which is further characterized to include the step of:
introducing stabilizing material into said earth material during said cutting and comminuting.

3. A method of performing controlled depth stabilization as set forth in claim 2 wherein said step of introducing comprises:
spraying stabilizing liquid into said earth material.

4. A method for performing controlled depth stabilization as set forth in claim 2 wherein said step of introducing comprises:
interjecting dry stabilizing material into said earth material.

5. A method of performing controlled depth stabilization as set forth in claim 3 wherein said stabilizing liquid is oil.

6. A method for performing controlled depth stabilization as set forth in claim 3 wherein said stabilizing liquid is water.

7. A method for performing controlled depth stabilization as set forth in claim 4 wherein said dry stabilizing material is lime.

8. A method for performing controlled depth stabilization as set forth in claim 1 wherein said stop of providing a reference line comprises:
supporting a stringline at spaced positions along one or both sides of said roadway.

9. A method for performing controlled depth stabilization as set forth in claim 1 which includes the steps of:
continuously controlling implements for cutting and comminuting, and for spreading such that said second level is maintained a constant distance above said first level and below said reference line.

10. A method for performing controlled depth stabilization as set forth in claim 8 which includes the steps of:
continuously controlling implements for cutting and comminuting, and for spreading such that said second level is maintained a constant distance above said first level and below said string line.

11. A method for performing controlled depth stabilization as set forth in claim 1 which includes the step of:
controlling the rate of said cutting and comminuting of said native earth material thereby to limit the average particle size to a selected standard.

12. A method for performing controlled depth stabilization as set forth in claim 9 which includes the step of:
controlling the rate of said cutting and comminuting of said native earth material thereby to limit the average particle size to a selected standard.

13. A method for performing controlled depth stabilization of native earth material in situ to form a constant profile layer along a predetermined roadway path comprising the steps of:
providing a reference line indicating the relative elevation level of said layer;
cutting and comminuting said native earth material along said roadway path down to a first level which is disposed a predetermined constant distance from said reference line;
simultaneously spreading said comminuted earth material approximately evenly on said roadway to a second level which is disposed a predetermined distance between said reference line and first level; and
simultaneously trimming said spread and comminuted earth material at said second level which is continually maintained at a preset distance above said first level to provide said constant profile layer of the comminuted native earth material.