APPARATUS FOR DRIVING A ROD INTO THE GROUND FOR DETERMINING SOIL QUALITIES AT DIFFERENT DEPTHS

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ABSTRACT OF THE DISCLOSURE

An apparatus for driving a rod into the ground for determining soil qualities at different depths, comprising a stand for supporting a driving device for the rod which consists of tube sections screwed one to another, said driving device being adjustable on said stand into substantially vertical and substantially horizontal positions, said driving device comprising a pair of rotatably mounted clamping rollers and means for rotating said rollers mounted in two casing parts which are movable relative to each other for adjusting the distance between the rollers, said rollers having circumferential grooves for clamping a cylindrical rod between the rollers, said casing parts being adapted to be urged against each other by compression spring means, the tension of said compression spring means being adjustable by at least one screw member, the lower end of said rod being secured to a vane member for torque measuring consisting of a lower part and an upper part, said parts being connected to each other by means of a clutch arranged to permit rotation of the lower part relative to the upper part between two end positions, said lower part having a plurality of equally spaced vanes which are inclined relative to the longitudinal direction of the vane member, whereby to turn said lower part to one end position as the vane member is driven down in the ground.

These objects and advantages of the invention are attained by an apparatus as defined in the appended claims. A suitable embodiment of the apparatus according to the invention is exemplified in the annexed drawings in which—

FIG. 1 is a lateral elevation of the apparatus combined with a recording instrument for measuring the shear strength in soil layers at different levels,

FIG. 2 is a lateral elevation of a vane member devised in accordance with the invention and adapted to be used in the apparatus shown in FIG. 1 for measuring the shear strength of the soil layers,

FIG. 3 is an enlarged longitudinal sectional view of a lost motion clutch inserted between the vane member shown in FIG. 2 and the boring rod which consists of lengthening pieces screwed one to another and which may be driven down by means of the apparatus according to the invention,

FIG. 4 is a cross-sectional view taken along the line 4—4 in FIG. 3,

FIG. 5 is a lateral elevation, with parts broken away, of a driving device according to the invention comprising clamping rollers and contained in the apparatus shown in FIG. 1,

FIG. 6 is a sectional view taken along the line 6—6 in FIG. 5,

FIG. 7 is a longitudinal sectional view of the recording pointer instrument used for measuring the shear strength,

FIG. 7a is an enlarged sectional view of part of FIG. 7 comprising a member for holding down a waxed paper on which there is obtained a curve showing the relation between the variations of the torque and the angular movement of the rod and the vane member,

FIG. 8 is a section taken along the line 8—8 in FIG. 7,

FIG. 9 is a plan of the instrument as viewed from the line 9 in FIG. 7 after removal of the cover and the plate that supports the recording paper,

FIG. 10 is a plan with the cover removed and illustrating a recording paper on which a torque curve is drawn,

FIG. 11 is a diagrammatic exploded perspective view of the main parts of the instrument,

FIG. 12 is a longitudinal sectional view with parts broken away of a conventional piston sampler comprising a cylinder for clay or soil samples,

FIG. 13 illustrates the apparatus according to the invention in combination with the piston sampler shown in FIG. 12 and explains how the apparatus according to the invention is used for taking clay samples out of the cylinder in a simple and novel manner according to the invention,

FIG. 14 is an enlarged sectional view of an externally threaded short pipe which is secured to the upper end of the casing of the rollers and on which the front part of the cylinder can be screwed as illustrated, and

FIG. 15 is a diagrammatic perspective view of an arm adapted to the end of the fore part of the cylinder which in FIG. 13 is screwed to the short pipe and houses the sampling tubes.

Referring to FIGS. 1 and 13 the main parts of the apparatus consist of a foldable stand 20, a casing 22 for the driving device for driving down a rod 23, said casing being mounted on the stand by means of a transverse pivot 21, an instrument 24 detachably secured to the casing 22 for rotating the rod and recording the torque acting on the rod, a vane member 25 connected to a clutch 26 as shown in FIGS. 2 and 3, and a piston sampler 27 illustrated in FIGS. 12 and 13.

The stand of the apparatus comprises a rectangular bottom frame having two long sides 28 and two short sides 29 and being anchored to the ground surface by means of hold down bolts, not shown. Detachably con-
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connected to the long sides are two vertical arms 30 (only one being shown) which are interconnected by a bow arcuate brace 31 and by upper cross braces 32, 33. The rod 33 extends freely between the arms 30. The top ends of the arms support the casing 22 which houses the clamping rollers shown in FIGS. 5 and 6 and constituting the driving device of the apparatus. The two arms 30 are at some extent adjustable in exactly vertical positions (FIGS. 1 and 13). To this end they are pivotally secured at their lower ends 34 and are maintained in position by means of an adjustable telescopic stay consisting of two sleeves 35, 36 which are displaceable relative each other and can be locked to each other in desired relative position by means of a clamping member 37.

The casing 22 can be adjusted and locked in a vertical position as shown in FIG. 1, or swung to a horizontal position as shown in FIG. 13. In the vertical position the casing is locked by means of a stay 38.

In order to fold the stand, the instrument 24 is removed and the lower ends of the arms 30 are detached from the frame 28, 29 so that the arms 30 and the casing 22 can be placed one above another. The telescopic stay 35, 36 is turned down to the frame. In this position the parts form a compact and comparatively light aggregate that can readily be carried by two men.

As is known from the art the rod 23 consists of a plurality of pipe sections 23a which according as the rod is driven down into the ground are screwed one after another to the end of the topmost pipe section whereby to lengthen the rod.

As will appear from the following description the apparatus is constructed such that it can be used both for torque measurements for determining the shear strength of soil layers as shown in FIG. 1 and in combination with a piston sampler as shown in FIG. 13. Within the scope of the invention it is, of course, possible to devise the apparatus with regard to the requirements for torque measuring only in which case the diameter of the rod 23 can be smaller with consequent reduction of the resistance to penetration as compared with piston sampling. In this case it also is possible to reduce the power of the device for driving down the rod which means that a single pair of clamping rollers can be used instead of the two pairs of clamping rollers shown in FIGS. 5 and 6. If the apparatus is intended for piston sampling only the support 39 for the instrument 24 shown in FIG. 1 can be omitted as illustrated in FIG. 13. Of course, if desired the instrument support may be screwed to the casing 22 in FIG. 13.

As will be seen from FIGS. 5 and 6 the casing houses two pairs of cooperating clamping rollers 40, 41 and 42, 43 having circumferential grooves 44 which together form a guide means for the pipe section 23a shown in FIG. 6. The rollers 40, 42 located on one side of the pipe section or rod are rotatably mounted in a fixed part 45 of the casing which at its lower end has two lugs 46 for attachment to the arm 30 of the stand and a lug 47 for attachment to the stay 38. The clamping rollers on the opposite side of the rod are rotatably mounted in a movable casing part 48 carried by a pair of threaded studs 49, 50 which are screwed into the casing part 48 and extend freely each through a cylindrical bore 51 in the fixed casing part 45. Nuts 52 on the outer ends of the studs are in contact with a cross piece 53 which is displaceably mounted on the studs 49, 50. Between this cross piece and the bottoms 54 of cylindrical recesses 55 in the fixed casing part there are inserted two rows of cup springs 56 providing the necessary clamping action in the fixed casing part 45 on either side of the rod 23a for permitting the rollers to adapt themselves to irregularities, if any, of the rod. By means of the nuts 52 the rod can be clamped between the rollers for driving the rod in either direction or disengaged from the rollers if it is desired to rotate the rod such as for torque measurement of the type to be described hereinbelow.

The shafts of the rollers are provided with sprocket wheels 57, 58, 59, 60 for connecting the upper rollers 42, 43 to the lower rollers 40, 41 by means of chains 61, 62 shown in FIG. 5. The pinion and the gear wheel 63 are provided with studs 66, 67a for attachment to a driving motor or handle. The stud 67a is used for fast driving and may to this end be connected to an internal combustion engine, whereas the stud 66 is used for slow driving with greater force by means of a handle.

The driving device illustrated permits exertion of thrusts on the rod of the order of 6 tons which is more than sufficient for the purpose in consideration. As will be seen from FIGS. 5 and 6 the driving device is compact and simple and consequently comparatively cheap in manufacture.

The two parts 45, 48 of the casing are surrounded by a two part cover 67 one half of which is shown in FIG. 5, whereas both halves of the cover are omitted in FIG. 6 for the sake of clearness. As will be apparent from FIGS. 13 and 13 this cover forms part of the instrument 24.

If only one pair of clamping rollers is used, for instance the lower rollers 40, 41, in which case the apparatus is used for torque measuring only, the movable casing part 48 including one of the clamping rollers may be pivotally mounted on the fixed casing part 45 which carries the other clamping roller. Even in this case cup springs are provided for exerting the desired resilient pressure between the rollers and the rod.

For determining the shear strength by measuring the resistance to rotation of the rod and the vane member according to the invention shown in FIGS. 2 and 3 use is made of the instrument 24 the details of which will be described with reference to FIGS. 7 to 11.

After insertion of the first tube section 23a between the rollers 40, 41 and 42, 43 the lower end of the tube is connected to the vane member 25, 26 shown in FIG. 2. The vane member consists of two parts, namely, an upper part in the form of a sleeve 68 to which is screwed a shaft 69 adapted to be screwed to the lower end of said tube section, and a lower part comprising a shaft 70 having secured thereto a plurality of radial vanes 71 extending axially along the shaft. In the embodiment exemplified the shaft 70 is provided with four vanes. As indicated in FIG. 2 the vanes are slightly inclined relative to the axis of the shaft, the angle of inclination being about 1°. The upper and lower parts of the vane member are connected to each other by means of the clutch 26 which comprises a piston 72 which is rigidly secured to the lower part 70 and by means of upper and lower needle bearings 73, 74 mounted for angular movement within the sleeve 68. A transverse stop pin 75 extends through a transverse hole 76 in the piston and has its ends 75a fastened in opposite holes in the wall of the sleeve 68. The hole in the piston widens in both directions from the central part of the piston so as to permit angular movement of the piston relative to the sleeve between two end positions. This shape of the hole 76 is suitably obtained by drilling a hole through the piston and retaining the drilling tool while turning the piston through the desired angle. This angle is preferably between 10° and 15° which in combination with the above named inclination of the vanes 71 results in that the lower part of the vane member will be turned from one end position to the other one and simultaneously lowered in the ground about 40 inches which is the usual distance between two test places.

Due to the needle bearings the upper and lower parts are movable relative each other without substantial friction which is desirable for reasons explained hereinbelow. The needle bearings are protected from soil and water by rubber protective sleeves 77 over the outer ends of the roller rods.

While the vane member is driven down it is forced to one of its end positions. If thereupon the rod is turned in the direction which results in that the upper part is shifted to the other end position, that is that the pin 75 moves through 15° in the hole 76 in the piston, the vane member will be stationary while the rod is turned as a whole by means of the instrument 24. It will be understood that during the last-mentioned operation the clamping rollers 40 to
43 are disengaged from the rod. During this rotation the resistance to rotation is recorded in the manner described below. To begin with there is only obtained the resistance to rotation to the rod. In the second of the above named end positions the vane member takes place in the rotation. Consequently, the resistance to rotation of the vane member will be recorded together with the resistance to rotation of the rod. When the clay breaks there are obtained a maximum resistance at a maximum torque, and by subtracting the torque required to rotate the rod from said maximum torque the difference is obtained the torque that caused the friction. The ultimate torque is directly proportional to the shear strength of the clay or soil. By means of the instrument illustrated in FIGS. 7 to 11 the torque variations can be recorded.

Referring to FIG. 7 the instrument comprises a casing 77 having a bottom ring 78 to be secured to the support 39 (FIG. 1) provided on the casing of the clamping rollers. At its top end the casing 77 has a detachable cover 79 with a glass plate 80. As will be seen from FIG. 7 the tube sections 23a extend straight through the casing thereby facilitating measurements at different levels because the casing can remain on its support as the rod is lengthened at its top end by additional tube sections.

A central sleeve 81 extending through the casing forms a guide member for the rod. By means of ball bearings the sleeve 81 is rotatably mounted in an external sleeve 82 which is screwed to the bottom 84 of the casing. Rotatably mounted on the external sleeve 82 is a worm wheel 85 adapted to be driven by a worm 86 which is rotatably mounted in the casing and prevented from axial movement. This worm carries a second worm wheel, not shown, adapted to be driven by a second worm 87 mounted in the casing. The gear ratio of the last-named worm gear is of the order of 1:2000 and the gear ratio of the first-named worm gear is of the order of 1:60. While the worm gear 85, 86 is engaged the other worm gear is disengaged.

Both gears are used for rotating the rod and the vane member in the manner described below.

Secured to the worm wheel 85 is a circular plate 88 which at its edge has an upright lug 89 secured to one end 90 of a plate spring 91. As shown in FIG. 8 the plate spring is circularly bent and substantially concentric with the sleeve 81. By means of a pin 92 the other end 93 of the spring is connected to an arm 94 secured to the sleeve 81. Two uprights 95 secured to the arm 94 support a large toothed segment 96 the rim of which is concentric with the sleeve 81.

Mounted on the plate 88 are three uprights 97 extending above the arm 94 and supporting an oblong plate 98 (FIG. 9) one end of which extends close to the wall of the casing. Near this end a shaft 99 is rotatably mounted in ball bearings. The lower end of this shaft carries a small toothed segment 100 cooperating with, and adapted to roll on, the large toothed segment 96. The upper end of the shaft 99 carries a pointer 101 the pointed end 102 of which is adapted to draw a curve on a waxed recording paper 103 (FIG. 7b) which rests on a supporting plate 104 secured to the oblong plate 98. The central part of the circular measuring paper is connected to the cover 80 by means of a clamping sleeve 105 which is secured to the cover and holds the paper in contact with a rotatably mounted ring 106. This ring is supported by the outer race 107 of a ball bearing the inner race 108 of which is secured to the sleeve 81. Consequently, the paper will be stationary relative to the casing while the supporting plate 104 is rotated together with the worm wheel 85.

At its lower end the sleeve 81 is provided with an overrun roller clutch 109 of conventional type for connecting the sleeve to the rod 23 upon rotation in the direction used for torque determination.

As the rod is rotated by means of the worms 86 or 87 of the instrument a curve such as represented by way of example in FIG. 10 is drawn on the paper 103. The zero line 110 indicates the position of the sharp end of the pointer if no torque is exerted. During rotation of the rod for taking up the lost motion of the clutch in the vane borer there is obtained a torque MF corresponding to the resistance of rotation of the rod.

Power is transmitted from the worm 86 or 87 to the rod 23a via the plate spring 91 which is tensioned in response to the load, i.e. the resistance to rotation. Therefore it follows that the ends 90, 92 of the spring 91 will approach each other in response to the increasing torque. This relative movement between the ends of the spring results in a deflection of the pointer proportional to the torque. During rotation of the worm wheel the end of the spring and the large toothed segment 56 will travel a longer distance than the small toothed segment 100 resulting in that the small segment will roll on the large segment. Consequently, the shaft 99 will be rotated through an angle proportional to the torque exerted on the rod, and this deflection can be directly read from the curve shown in FIG. 10.

During this initial recording and up to the point where the clay breaks the low ratio worm 87 is used to obtain a slow rotation and consequently, an exact determination of the breaking point.

After the lost motion of the clutch 26 has been taken up the vane member 25 also takes part in the rotation. The resulting increased resistance to rotation is represented by a comparatively steep and smoothly ascending curve 111 which terminates at an apex 112 that represents the point where the soil or clay breaks around the vane borer, Therupon, the curve descends rapidly either in two steps as shown or directly to a value near the zero line. Then the resistance to rotation is dependent on the presence, if any, of stones or other obstacles in the clay. Consequently, also the part 113 of the curve can give some information about the character of the clay. During the corresponding stirring movement of the vane borer the high ratio worm 86 is used to obtain a faster final rotation of the vane member.

Due to the fact that the instrument is graduated in advance a direct reading of the shear strength of the clay can be taken from the resulting curve. The decisive distance to be measured is the radial distance MS between the apex of the curve and the zero line minus the torque MF obtained during rotation of the rod only. Further, it is possible to determine the angle Q which is proportional to the angular movement of the vane borer preceding the breaking point. To determine the real angle of rotation of the vane member consideration has to be paid to the torsional resiliency of the rod carrying the vane borer and to the deflection of the spring. The characteristics of the spring 91 and the torsion bar formed by the rod 23 can be easily determined, for instance empirically so that the angles of deformation of these two elements at varying torques can be directly obtained from the curve. These angles of deformation are then subtracted from the angle of rotation Q to obtain the angle through which the vane member has rotated prior to the fracture.

As previously mentioned the driving device of the apparatus according to the invention can be advantageously used for driving down a vane sampler 27 of known type illustrated in FIG. 12. The piston sampler consists of a two-part cylinder comprising a back part 114 having an extension pipe 115 adapted to be screwed to the lower end of the rod 23. The fore part 116 of the cylinder is externally threaded at 117 and can be screwed onto the front end of the back part 114. Within the fore part of the cylinder a piston 118 connected to a short pipe 119 is movable between a front end position shown in FIG. 12 in which it closes the front end of the cylinder and a rear position shown in FIG. 13 in which the fore part 116 of the cylinder indicated by chain-dotted lines is detached and instead screwed to a short pipe 120 secured to the casing 22 of the clamping rollers. This short pipe has external threads 121 fitting the internal threads 117 of the fore part 116 of the cylinder.
While the sampler is driven down the piston 118 is locked in its position by means of a ball lock 122 which locates the rear end of the piston rod 119 and is disengageable by means of a central lock pin 123 extending between the balls. The rear end of this pin is provided with a snap clutch 124 adapted to engage a cone 125. This cone is carried by a steel strip 126 and is dropped through the two sections after the cylinder 114 and 116 has been driven down to the desired level. After the snap clutch 124 has taken hold of the cone 125 the strip 126 is slightly withdrawn so as to disengage the lock pin 123 resulting in that the ball lock releases the piston whereby to permit for instance clay to be forced into the core part of the cylinder upon driving down of the sampler. The entering clay forces the piston back to its rear end position. In a manner known so for the core part of the cylinder contains a plurality of consecutive sampling tubes 127 of for instance plastic, the length of which corresponds to the length of the samples to be taken. Since the samples are kept in the tubes 127 while taking out the cylinder they will not be damaged or disturbed.

While the sampler is driven down and pulled up the casing 22 of the clamping rollers assumes the vertical position shown in FIG. 1. When the piston sampler is advanced between the vertical arms 30 of the boring stand the casing 22 is turned to the horizontal position shown in FIG. 13. Thereupon the core part 116 of the cylinder containing the sampling tubes 127 is screwed off. Secured to the upper side of the casing 22 is the above named short pipe 120 through which the end of the tube section 23a is clamped between the rollers slightly protrudes. A plug 129a having an end plate 129 is inserted into the end of the tube section 23a. The diameter of the plate 129 corresponds substantially to the internal diameter of the core part of the cylinder so that the plate can be brought into contact with the end of the sampling tubes 127 which are contained in the part 116 of the cylinder and filled with clay 128. Then the core part 116 of the cylinder is screwed onto the short pipe 120 as shown in FIG. 13. Clamped to the free end of the part 116 of the cylinder is an arm 129b provided with a trough-shaped plate 130 adapted to receive the sampling tubes as they are forced out of the cylinder by means of the tube section 23a clamped between and driven by the rollers.

Due to the provision of the pipe 120 on the casing 22 of the rollers the apparatus according to the invention can be changed in a simple manner into a work table associated with devices for expelling the sampling tubes. This is rendered possible due to the special construction of the driving device in the form of clamping rollers and the connection pipe 120 secured to the casing. As a result the equipment is considerably simplified because hitherto it was necessary to use a separate working table with fastening means for the core part of the cylinder and special devices for expelling the plastic sleeves.

What we claim is:

1. An apparatus for driving a rod into the ground for determining soil qualities at different depths comprising a stand for supporting a driving device for the rod which consists of a number of sections screwed onto said stand, said driving device being adjustable on said stand into substantially vertical and substantially horizontal positions, said driving device comprising a pair of rotatably mounted clamping rollers and means for rotating said rollers mounted in said casing parts which are movable relative to each other for adjusting the distance between the rollers, said rollers having circumferential grooves for clamping a cylindrical rod between the rollers, said casing parts being adapted to be urged against each other by compression means, the tension of said compression means being adjustable by at least one screw member, the lower end of said rod being secured to a vane member for torque measuring consisting of a lower part and an upper part, said parts being connected to each other by means of a clutch arranged to permit rotation of the lower part relative to the upper part between two end positions, said lower part having a plurality of equally spaced vanes which are inclined relative to the longitudinal direction of the vane member, whereby to turn said lower part to one end position as the vane member is driven down in the ground.

2. An apparatus as claimed in claim 1 in which the angular distance between said end positions is between 10° and 15°.

3. An apparatus as claimed in claim 2 in which the inclination of the vane relative to the longitudinal direction of the vane member is about 1°.

4. An apparatus as claimed in claim 1 in which the clutch between the upper and lower part of the vane member comprises a sleeve which is secured to one of said parts and in which a piston secured to the other part is mounted for angular movement, said piston having a transverse hole through which extends a pin the ends of which are secured in the surrounding sleeve, and said hole being widened towards its ends on opposite sides of the piston whereby to permit a limited angular movement of the piston relative to said pin which is adapted to prevent relative axial movement between the sleeve and the piston.

5. An apparatus as claimed in claim 4 in which said piston is mounted by means of needle bearings provided above and below the transverse hole in the piston.

6. An apparatus as claimed in claim 1 in which the casing of the clamping rollers is provided with a support on which a recording torque-measuring instrument is detachably mounted, said instrument comprising a casing having a central guide means for said rod to be driven in either direction by means of the clamping rollers, said instrument casing being provided with a transmission for transmitting a twisting force to said rod from at least one manually operable drive screw mounted in the instrument casing and via a spring device and a clutch device, a pointer having a recording point and a circular recording paper, such as a waxed paper, said recording point and said paper being carried by members rotatable relative to each other about the axis of the instrument casing, one of said members being rigidly secured to the casing and the other member being adapted to be actuated in such a manner by the end of the spring device connectable to said rod, said shaft of the pointer being moved a distance proportional to the angular movement of the rod, the pointer being deflected in direct proportion to the relative movement between both ends of the spring device, whereby to record the resistance to rotation in the soil layer.

7. An apparatus as claimed in claim 6 in which the spring device consists of a circularly bent plate spring which is substantially concentric with the axis of the instrument casing, one end of the spring being drivenly connected with the drive screw, the other end of the spring being detachably connectible via a one-way clutch to said rod which is alternately freely rotatable and engageable between the clamping rollers, and said other end of the spring being secured to a rotatably mounted plate which forms a support for the circular recording paper adapted to be prevented from rotation, the shaft of said pointer being rotatably mounted in said supporting plate, said shaft of the pointer extending below said plate and being provided with a first toothed segment in engagement with a second toothed segment having a toothed rim concentric with the axis of the instrument casing, said second toothed segment being secured to the other end of said spring, whereby the first segment rolls on the second segment in response to the deflection of the spring.

8. An apparatus as claimed in claim 7 in which the guide means for said rod is in a sleeve extending axially through the instrument casing and having at its lower end an over-running clutch for engaging the sleeve with the rod in one direction of rotation, said sleeve carrying an arm which is secured to said other end of the spring and in turn carries said first toothed segment, a worm wheel
being concentrically mounted on the sleeve and carries a support which is secured to said one end of the spring and by means of uprights carries said plate together with bearing means for the shaft of the pointer.

9. An apparatus as claimed in claim 8 in which a ball bearing is provided at the upper end of the central rod-guiding sleeve, the inner race of said ball bearing being secured to the central sleeve and the outer race of the ball bearing carrying an angular plate, the instrument casing having a transparent cover located above the plate which carries the recording paper, and said central part of the cover being provided with a short clamping sleeve fitted on the guide sleeve for the rod, the lower end of said clamping sleeve being adapted upon application of said cover to hold the recording paper against said angular plate whereby to keep said paper stationary during rotation of the underlying plate together with the pointer carried thereby.

References Cited

UNITED STATES PATENTS

2,548,616 4/1951 Priestman et al. ----- 175—203 X
2,833,444 5/1958 Miller et al. -------- 73—84
3,265,268 8/1966 Buch et al. --------- 226—154

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