March 21, 1967 W. DEGEN 3,309,877

VIBRATOR FOR COMPACTING SOIL

Original Filed Sept. 7, 1960 3 Sheets-Sheet 1

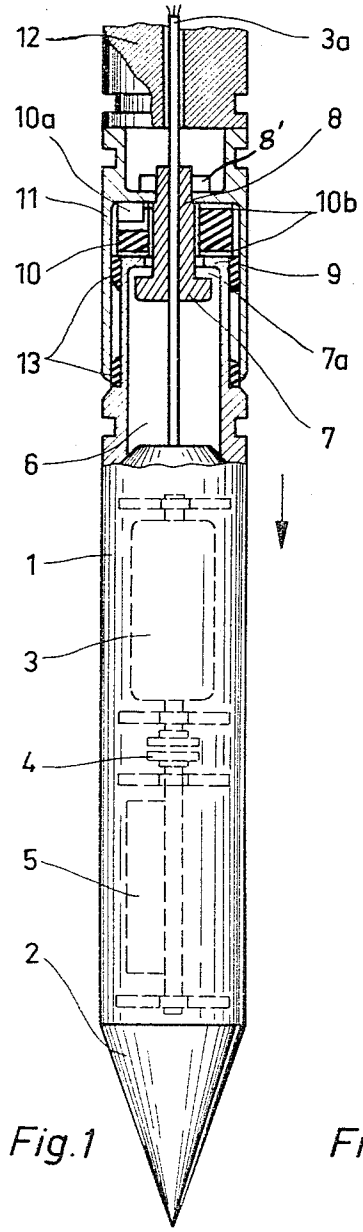


Fig.1

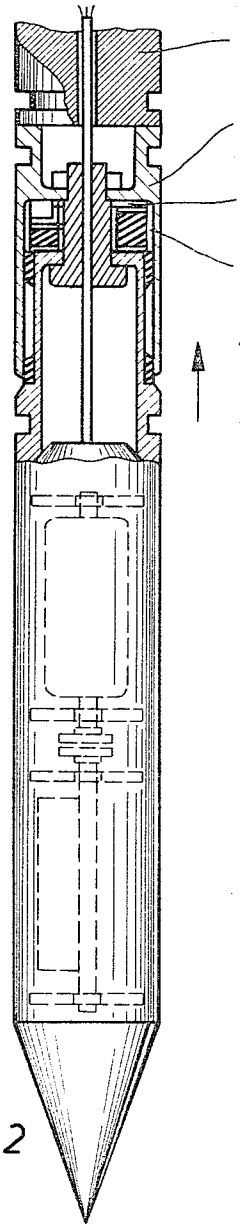


Fig.2

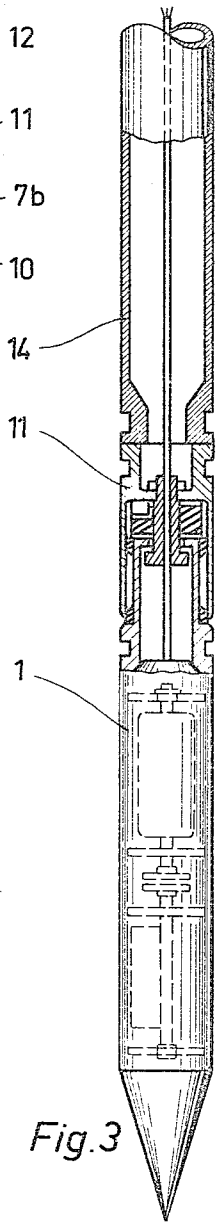


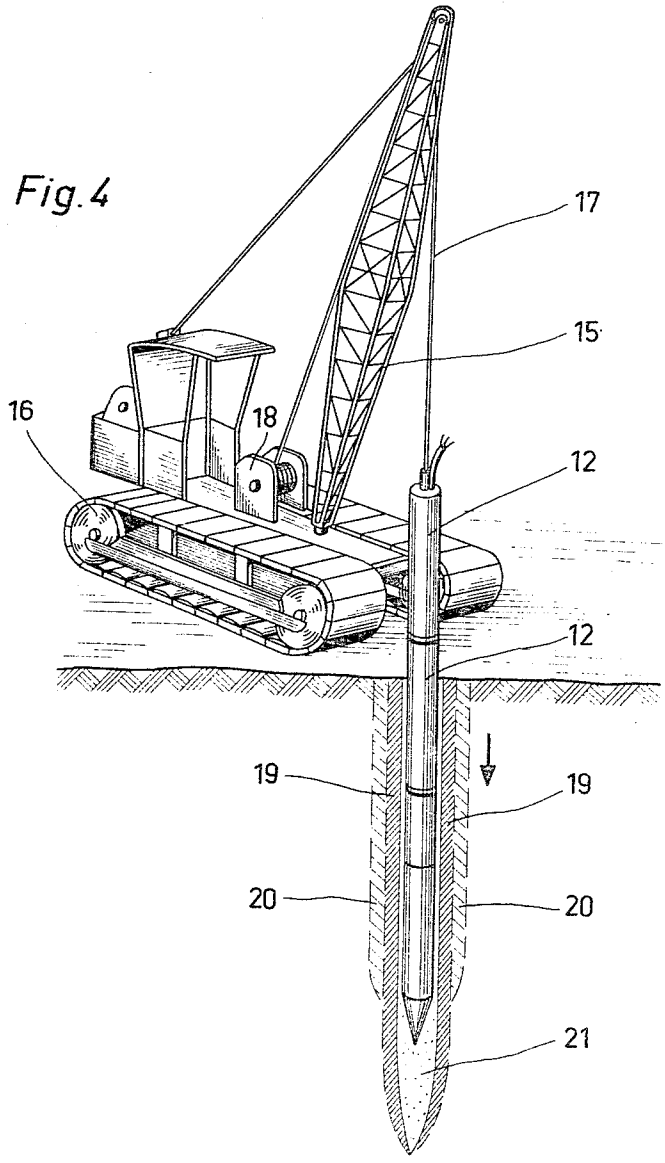
Fig.3

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Fig. 4



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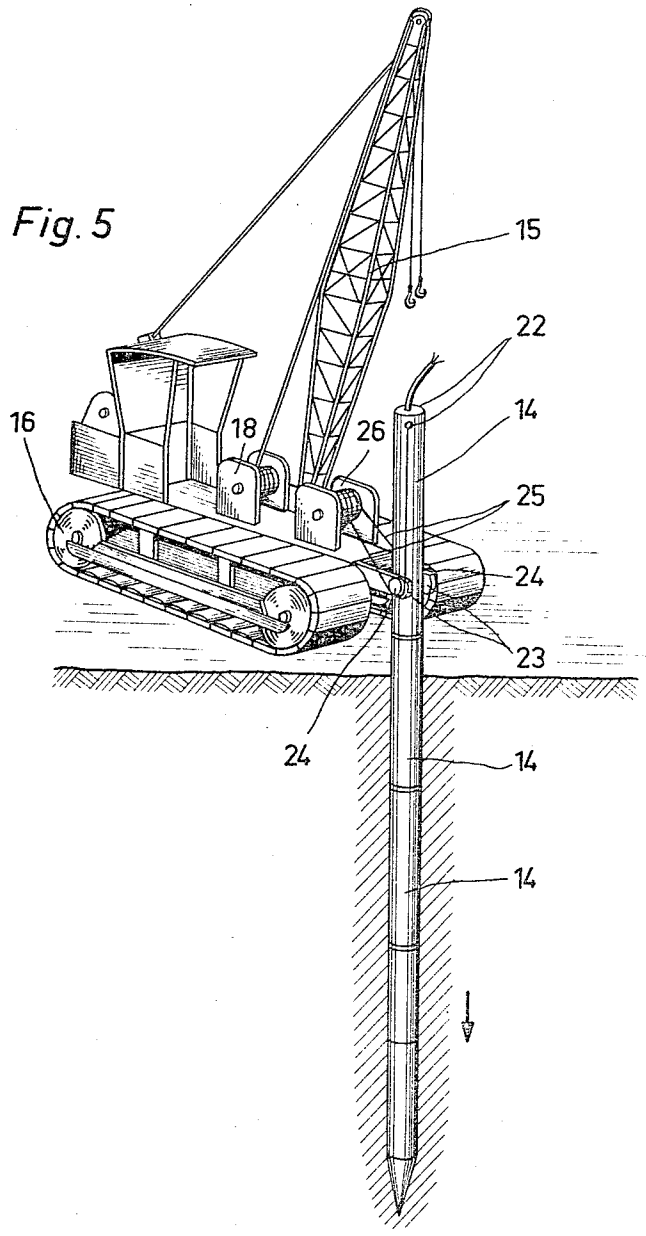
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Fig. 5



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VIBRATOR FOR COMPACTING SOIL

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Original application Sept. 7, 1960, Ser. No. 54,434, now Patent No. 3,246,223, dated Apr. 12, 1966. Divided and this application Jan. 27, 1966, Ser. No. 523,321
10 Claims. (Cl. 61—35)

This application is a division of my copending application Ser. No. 54,434, filed on Sept. 7, 1960, now Patent No. 3,246,223.

The present invention relates to a device for compacting soils, particularly for compacting coherent soils by means of an internal vibrator brought down to the necessary compacting depth even into soils so firm that they could heretofore not be penetrated by means of internal vibrators by the dry method, that is, without the use of an auxiliary liquid. The descending internal vibrator produces compacted firm columns of soil useful as foundations for buildings of all kinds.

The invention provides a soil immersion vibrator having a downwardly point of a length greater than the diameter of the vibrator and suspended from rods or tubes of the same diameter as the body of the vibrator. When the vibrator rotates at about 3000 revolutions per minute, the ratio between the lateral striking force in tons to the section of the vibrator body in dcm.^{2} is greater than 1.5. The vibrator is coupled by an oscillation damping connector to a source of supplemental vertical pressure while it is being lowered into the soil and is brought to the necessary compacting depth, whereafter the vibrator is lifted from the hole formed which is again filled with soil masses into which the vibrator is immersed. The cycle of lowering the vibrator, lifting the vibrator, and filling the hole is repeated until the vibrator of the invention can penetrate firm coherent soils to form a hole without the use of a liquid for converting the soil to a slip or slurry.

It is a further advantage of the invention that it does not require hardening agents introduced into the wall of the hole in order to solidify it.

In the cited types of soil, the method of the invention produces a column shaped zone of compacted soil which may extend a depth of twenty meters and is capable of carrying buildings.

It is a further advantage of the invention that the walls of the hole cannot collapse above the vibrator due to oscillations propagated in the soil.

Other objects, features and advantages of the invention will be pointed out in the following detailed description of preferred embodiments relating to the appended drawing in which:

FIG. 1 shows a vibrator of the invention with coupling and supplemental weight in elevational section;

FIG. 2 shows the vibrator of FIG. 1 in a different operative position;

FIG. 3 shows another vibrator arrangement;

FIG. 4 shows the vibrator with supplemental weight suspended from a track-laying vehicle, the view being in perspective and partly in section; and

FIG. 5 shows the apparatus of FIG. 4 in a different operative condition.

FIG. 1 shows a vibrator of the invention with the lower end of the suspending structure. The vibrator comprises a cylindrical casing **1** the bottom of which is closed by a coaxial conical cap **2**. The axial length of the cap **2** is greater than the diameter of the vibrator casing **1**. A motor **3** receiving electric current through a flexible cable **3***a*, and an eccentrially gyrating mass **5** connected to the output shaft of the motor by a coupling **4** are mounted within the vibrator casing **1** in a known manner. When the eccentrically mounted mass is rotated by the motor,

the vibrator performs an occillatory movement transverse to its axis which is transmitted to the surrounding soil. The amplitude of oscillation may amount to 0.5 inch. In order not to transmit these oscillations to the tubular suspension rods or supplemental weights **12** from which the vibrator is suspended and which have the same diameter as the said vibrator there is provided according to the invention, a coupling which reduces the transmission of oscillations to a minimum. For this purpose the lowermost supplemental weight **12** carries a stud **8** with head **7** which may be of disk- or arc-shaped configuration, the stud being suspended by means of a cross bar **8'** from a coaxial tubular element **11** which projects from the lower edge of the weight **12**. An oscillation dampening connector **10** which has the shape of an annular disk with cams **10***a* is inserted between the element **11** and the upper vibrator flange **9** to absorb torsion stresses. The stud **8** with the head **7** extends through the connector **10** which is a rubber element faced with metal disks **10***b*. The stud **8** also extends through the vibrator flange **9**, which covers the space **6** in the vibrator casing **1** in such a manner that the head **7** of the stud **8** can be arranged within it. This connection between the vibrator and the supplemental weight is surrounded in a telescopic manner by the tubular element **11** which is screwed firmly to the supplemental weight **12** in a conventional manner (not shown).

During lowering of the vibrator **1** the load of the weight **12** and of the rods nor weights, not visible in FIGS. 1 and 2, is applied to the vibrator **1** only through the connector **10** while the vibrator oscillations are absorbed within the rubber of the connector **10**. The stud **8** is of such length that, with the vibrator put on the soil or immersed therein, the head **7** is moved downward by the weight of the suspension rods **12** until it extends freely into the space **6**, and the upper vibrator flange **9** and the head **7** are separated by a gap **7***a*.

Because of the presence of interposed rings **13**, the tubular element **11** stiffens the vibrator casing against lateral bending so that the vibrator cannot take an oblique course within the soil.

FIG. 2 shows the same vibrator with supplemental weight during lifting of the device. The connector **10** is released from the weight **12**, and therefore from the rods, so that the gap **7***a* (FIG. 1) closes and a gap **7***b* is formed between the connector **10** and a radial face of the element **11**. The vibrator hangs freely from the head of the stud **8** whereby almost no oscillations are transmitted upwardly. Abutment of the head **7** against the underside of the flange **9** limits movement of the lowermost rod or weight **12** away from the vibrator casing **1** during lowering of the vibrator, as shown in FIG. 2.

FIG. 3 shows a vibrator of the same type as in FIGS. 1 and 2, but the rods or weights **12** are replaced by thinner walled tubes **14** of the same diameter as the vibrator and connected with the upper part of the element **11**. The tubes **14** are connected to the vibrator **1** by means of the same coupling as described in FIGS. 1 and 2.

FIGS. 4 and 5 illustrates the operation of the vibrators of the invention.

The vibrator is suspended by a rope **17** from a boom **15** mounted on a track-laying vehicle **16** and is lowered by means of a winch **18**. It penetrates the soil when the vibrator motor is running, whereby the soil is laterally displaced first by the point of the vibrator, and thereafter by the vibrator casing itself, and is compacted in zones **19** and **20** about the hole formed. The necessary lateral striking force is provided by the motor **3**, and a downward force is exerted by a string of rods or supplemental weights **12** which also serve as the vibrator suspension and which do not oscillate transversely because they are connected to the vibrator by the afore-described coupling. The lateral striking power of the vibrator is

concentrated on the soil walls axially coextensive with the vibrator.

Because of the tapering configuration of the vibrator point **2**, the soil is not compacted ahead of the vibrator during lowering so that the vibrator does not block its own path.

The vibrator with the supplemental weight is lowered to the desired depth and is lifted thereafter from the hole formed. The hole is filled with additional soil **21** and the vibrator is lowered again. This process may be repeated as many times as necessary until either a hole with firm compacted wall zones **19**, **20** has been formed or until the initially formed hole is filled to the surface with compacted soil, and the vibrator can no longer penetrate into the highly compacted soil. The depth of the compacted soil may be 20 meters and more in firm coherent soils and is limited by the combined length of the vibrator and its supporting rods.

It is particularly advantageous to use the arrangement shown in FIG. 5 in which the weight of the track-laying vehicle is used for exerting a vertical downward force on the vibrator. The track-laying vehicle has a fork-shaped arm **23** carrying two pulleys **24** over which two ropes **25** are guided from fastenings **22** on the outermost tube **14** above the arm **23** to a winch **26**. When the winch **26** pulls the ropes **25**, the weight of the track-laying vehicle counteracts the resistance of the soil to penetration by the vibrator. The winch **26** thus provides motive power for moving the lowermost suspension tube **14** downward toward the vibrator whereas the winch **18** provides motive power for movement in the opposite direction. Motion is transmitted by the ropes **17**, **25** and the other tubes **14**.

The apparatus shown in FIG. 5 is operated in the same manner as described with reference to FIG. 4, but tilting of the vibrator is avoided, and handling of the relatively long device, particularly when transporting the device from one soil compacting spot to another, is facilitated. Because of the supplemental loading of the vibrator by the ropes **25**, the tubes **14** which transmit downward motion from the traction ropes **25** to the vibrator may be relatively light.

Immersion vibrators with rotating unbalanced masses for compacting soil are known per se but they normally can penetrate into the soil under their own weight only in the case of sandy soils which are transformed into a slurry by a liquid. The rods on which they are suspended are under stress only while the vibrator is being lifted, so that the connector interposed between the vibrator and the suspension unit is stressed in tension only.

The vibrator described, for example, in Patent No. 2,229,912 may penetrate to a shallow depth in soft soils. It is not able to penetrate into coherent firm soils to depths of 20 and more yards, even if the bore hole walls of a hole made with such a vibrator would not collapse. Such collapsing could not be prevented by injection of solidification agents because the walls could not harden quickly enough.

I claim:

1. A vibrator arrangement for compacting soil, comprising

(a) an elongated vibrator member having a vertically extending longitudinal axis;

(b) oscillator meanss for oscillating said member transversely of said axis;

(c) a suspension rod member superposed on said vibrator member and elongated in the direction of said axis;

(d) moving means for moving said members axially toward and away from each other while said vibrator member engages soil to be compacted;

(e) resilient damping means interposed between said members for simultaneous abutting engagement therewith when said members axially move toward each other; and

(f) abutment means on each of said members engageable for limiting axial movement of said members away from each other, said abutment means being disengaged when said damping means is in simultaneous engagement with said members.

2. A vibrator arrangement as set forth in claim **1**, wherein said vibrator member has a portion substantially cylindrical about said axis, and another coaxial conical portion extending from said cylindrical portion in a direction away from said rod member, and tapering to a point, the axial length of said conical portion being greater than the diameter of said cylindrical portion.

3. A vibrator arrangement as set forth in claim **1**, wherein said moving means include a support, a source of motive power on said support, and motion transmitting means connected to said source and to said rod member for alternatingly moving the same under the power of said source in a direction toward and away from said oscillator member.

4. A vibrator arrangement as set forth in claim **1**, further comprising a tubular stiffening element defining a bore therein, said stiffening element axially projecting from one of said members, and said bore receiving said damping means and an axially terminal portion of the other member; and resilient spacer means interposed between said element and said termianl portion.

5. A vibrator arrangement as set forth in claim **1**, wherein a portion of one of said members is formed with an axially open cavity opposite the other member and carries a flange member radially extending inward of said cavity, said flange member having a radially extending face in said cavity constituting one of said abutment means; and the other one of said members carries a projection axially extending past said flange member into said cavity, the free end portion of said projection being radially enlarged and constituting the other one of said abutment means, said abutment means engaging each other when said projection moves outward of said cavity.

6. A vibrator arrangement as set forth in claim **5**, further comprising a tubular stiffening element defining a bore therein, said stiffening element axially projecting from said other member, and said bore receiving said damping means, said flange member and the portion of said one member carrying said flange member; and resilient spacer means interposed between said stiffening element and said portion of said one member.

7. A vibrator arrangement as set forth in claim **1**, wherein said vibrator member and said rod member are of substantially cylindrical shape and have substantially the same diameter about a common axis.

8. An arrangement as set forth in claim **1**, wherein said moving means include a support adapted to be placed on the soil to be compacted; guide pulley means secured on said support; a tension member trained over said pulley means and having two end portions, one of said end portions extending upwardly from said pulley means and being fastened to a portion of said suspension rod member; and tensioning means on said support engaging the other end portion of said tension member for tensioning the same, whereby downward force is exerted on said rod member.

9. An arrangement as set forth in claim **8**, further comprising means for transmitting the weight of said support to said rod member, whereby additional downward force is exerted on said rod member.

10. A soil compacting arrangement which comprises:

(a) a vibrator member having an end portion, said end portion tapering downward in the normal operating position of said member; in which said member is embedded in the soil to be compacted;

(b) oscillator means for oscillating said member in a horizontal plane while in said operating position;

(c) motion transmitting means upwardly extending from said vibrator member while the same is in

said operating position and being of sufficient length so that a portion of said motion transmitting means projects from said soil when said vibrator member is embedded to a predetermined depth;

(d) traction means for exerting downward traction on said portion of said motion transmitting means, while said vibrator member is being oscillated, said traction being transmitted by said motion transmitting means to said vibrator member as a downward force, whereby a vertically elongated opening is formed above said member, and soil is compacted about said opening;

(e) means for preventing the compacted soil from entering said opening; and

(f) means for preventing transmission of oscillating movement from said vibrator member to said portion of said motion transmitting means.

References Cited by the Examiner

UNITED STATES PATENTS

2,667,749 2/1954 Steuerman ---------- 61—36

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JACOB SHAPIRO, *Examiner.*