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PROVISIONAL APPLICATION FOR:

APPARATUS AND METHOD TO ENHANCE THE UTILITY OF HYDRODYNAMIC COMPACTION MACHINE

The apparatus and method described herein are believed to constitute substantial benefits towards the utility and performance of the hydrodynamic compaction machine which is defined in US Patent 6,554,543 and to the groundwater cleanup configuration described in US Patent 8,419,316. Both these patents are the intellectual property of the current claimant as sole inventor of this application.

The novelty cited here is mainly applicable to the Ground Improvement sector of geotechnical engineering and environmental remediation, however, it may have some bearing on the petroleum industry.

Improvements Proposed Herein

The environment in which the hydrodynamic compactor is typically put to work is within relatively weak or loose soils at some depth below the water table. Depending on the project, this tool will be deployed for the purposes of improving the engineering parameters on which the behaviour of the soil or other particulate mass depends for stability. In other situations it may be employed to withdraw contaminated water from the ground surrounding it for environmental reasons. In such cases it is normal practice to push the machine down to the desired depth by applying an external vertical force to it. This force may be generated by such means as a custom designed hydraulic piston attached to a weighty deployment vehicle.

One of the benefits associated with the incorporation of the apparatus cited herein is its capacity to produce vertical impact blows internally at the bottom end of the apparatus, in combination with the lubricating of the outer cylindrical surface of the compactor by means of pressurised water exhausted locally, could in many cases empower the machine to enter the ground itself without need for the application of an externally applied force.

In weaker ground environments such as deltaic deposits and mine tailings of various gradations, the filter component of the well screen may be rendered useless/inoperative by virtue of the open spaces between its helically wound wire filter being plugged by cohesive layers existing within the material to be treated. Here is where a second benefit of this apparatus can be brought into play to rectify this situation by removing such smearing. And this benefit can be attained while the machine is at depth, in other words, without having to withdraw and expose the well screen above ground level. This is affected by the apparatus emitting pressurised water jets up between the ribs of the well screen while at the same time causing the screen to vibrate vertically.

Details of Apparatus

For the purpose of describing the apparatus and explaining its operation it is considered best to do so in the specific case of its embodiment as a module added to the existing hydrodynamic compaction machine: consequently, the apparatus is symmetrical about its vertical axis.

Sketch 1 shows the adaption of the bottom end of a hydrodynamic compactor required in order to avail of the novel functions associated with this module. The encasing parts are a nose cone shaped to suit ground penetration, and above that, a standard off-the-shelf well screen. Typically the nose cone is formed from mild steel and the well screen is made of stainless steel, as befits a part often in contact with potable water. Here the well screen is supported by a coaxial steel tube closely fitting inside.

A groove is cut around the top perimeter of the nose cone immediately beneath the well screen ribs and of the same width as the ribs. A plurality of holes are drilled through the shoulder of the nose cone from this groove so as to intercept the large cylindrical space reamed out of the inner cone. The inclination of these holes is made so as to align with the bottom shape of that inner space.

The inventor believes that the central and vital feature of the spiral/helical coupling is a novelty introduced into mechanics by himself. It consists of two equal parts, one resting on the other in a mirror-image configuration. Although "helix" is perhaps the more technically correct word, nevertheless, since the image of a spiral staircase is more familiar, the adjective "spiral" is used hereinafter. It is appropriate to remark here that since both halves of the spiral coupling are designed to be repeatedly subjected to impact loading that these parts should be pre-treated for stress relief and case hardened.

Essentially, this coupling's utility is as follows: When the top half is rotated in one direction the two parts remain with their interfaces intimately in contact, whereas, as illustrated in Sketch 2, when the top half is rotated in the opposite direction and the bottom half is denied rotation, then the top half will ride up on the lower half. As soon as it has completed a full turn and is no longer supported from below it will then drop over/off the lip of the lower half and fall into its original place against the lower half. Pawls are installed in the wall of the cone shoulder to constrain the rotation of the lower half of the spiral coupling.

A concentric metal rod, referred to as a hanger, is embedded within the upper coupling half and after passing freely through the lower coupling half, then enters the dead weight. Consequently, both the hanger and the dead weight are forced to move vertically in conformity with the position of the upper half of the spiral coupling. The dead weight is formed of metal, and advantageously, to some extent is composed of lead (plumbium). The dimensions of the hanger are chosen so that when the two halves of the spiral coupling are mated and moving in the same direction, then the hanger is held out of contact with the dead load.

Axial rotation is provided by a drive shaft powered from above. This rotation is conveyed to the top half of the spiral coupling initially through a spline shaft and then, by a drive key interacting with a slotted connection. The spline shaft is provided with some vertical slack, as is the drive key. This is to prevent vertical forces emanating from the dynamics involved in the movements of the dead weight from entering the drive shaft, and thereby effecting mechanisms further up the drive chain.

Sketch 3 shows the details exposed by the horizontal Section A-A of Sketch 1 which passes through the body of the compactor at the level of the drive key and slotted connection.

Sketch 4 shows detail of the water passageways provided for the escape of the water entrapped below the dead weight once the top half of the spiral coupling collapses onto the bottom half of this coupling. Here it can be seen how the discharge ends of these vents enter the circumferential water groove, thereby avoiding their blockage by the well screen ribs.

Sketch 5 shows, at an enlarged scale, the vertical positions of the drive key and the unengaged nature of the bottom of the hanger during the clockwise rotation of the drive shaft when the two halves of the spiral coupling are fully engaged with one another. This situation prevails during the time when the compactor is working in the vibration-cum-dewatering mode.

Sketch 6 shows the upper half of the spiral coupling at the extreme end of its rotation, when it is at the very point of dropping onto the lower half of the spiral coupling. Beyond this point the dead weigh will fall onto the nose cone resulting in a vertical blow as well as forcing the expulsion of the water beneath the weight from that space. This pressurized water escapes the area through the discharge conduits provided for this purpose. In this way each of these conduits will produce a jet of water entering the space between the drainage container and the ground outside the well screen, via the open spaces between the well screen ribs.

Method of operating the Apparatus

In each of its geotechnical applications the apparatus would be incorporated into the hydrodynamic compactor as its bottommost module, and so enshrined, would be positioned over the ground at the desired location by a mobile crane, or similar hoisting device. It is to be noted that irrespective of whether or not the compacter is enabled to enter the ground by means of the advantages offered by the additional novel module disclosed herein, it will still need to be progressively and gradually withdrawn to above ground surface level during the course of its ground improvement activity. It must therefore remain at all times tethered to the deployment vehicle.

The sketches presented here are drawn on the basis that rotation of the drive shaft in a clockwise direction, as seen from above, will result in the two halves of the spiral coupling coming together and rotating in unison; the pawls will allow unhindered/free rotation of the lower half. While the modules above this level will function normally, the dead weigh will remain quiescent and perform no function. This may be called the compactor's ground improvement mode.

In order to enter the ground penetration mode the procedure would be as follows:

- Deactivate the dewatering module.
- Add water at the top of the deployment casing in order to flood the well screen support tube and ensure it does not run dry.
- Activate counterclockwise rotation of the drive shaft at a rate of about 30 RPM.
- Set the nose cone on the ground and slacken the hoisting line.

In this mode the pawls will deny rotation of the lower half of the spiral coupling and cause the upper half to be gradually superelevated until it completes a full rotation (360°) after which point it will fall back onto the lower half again. Thus, each completed rotation of the drive shaft will result in a vertically downward hammer blow to the nose cone and a simultaneous expulsion of water out of the well screen into the surrounding ground. This extruded water serves to diminish the lateral soil pressures which otherwise restrain the cylindrical body from moving down.

During normal operation of the hydrodynamic compactor indications of well screen smearing/blockage will be evidenced by a reduction of seepage water discharge from the top of the deployment casing. At, or just below this point, or below a known cohesive seam/layer, the hoisting line should be locked in place and the same procedure as described above for the penetration mode enacted. The tamping action of the dead weight will cause vertical vibration along the length of the well screen and will produce inertial forces tending to shake loose soil caught in the openings of the helically wound wire.

<u>Other situations of potential benefit</u>

Despite the fact that the foregoing description of the apparatus has been, for convenience of illustration, explained in terms of specific embodiment restraints required by the particular demands of the hydrodynamic compactor's geometry, it will be obvious to those familiar/expert in the fields of water well installation and maintenance, and to petroleum drilling contractors, that this novelty can readily be adapted so as to be of some utility in their work.

For instance, in terms of water well installation it is possible that, in certain weeker soils, this apparatus would allow screens to be set in place and developed without the need for drilling a borehole. Also, it seems obvious that a modification of this tool could be used to renew the former conductivity of older wells, be they either sources of water or of petroleum.

Written by: William Eugene Hodge
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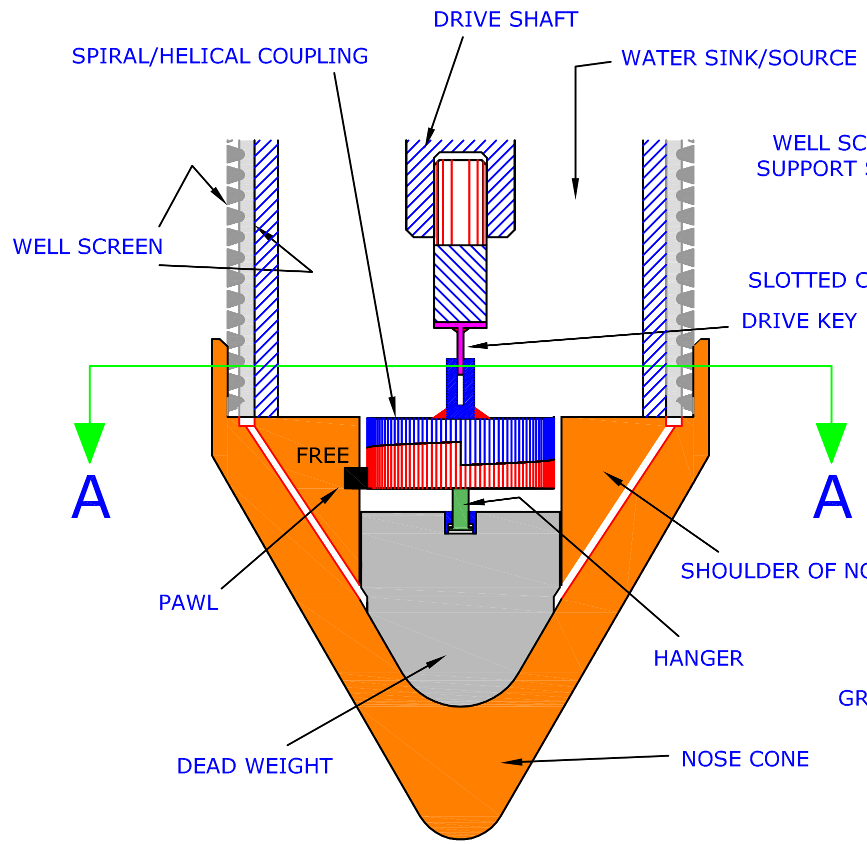
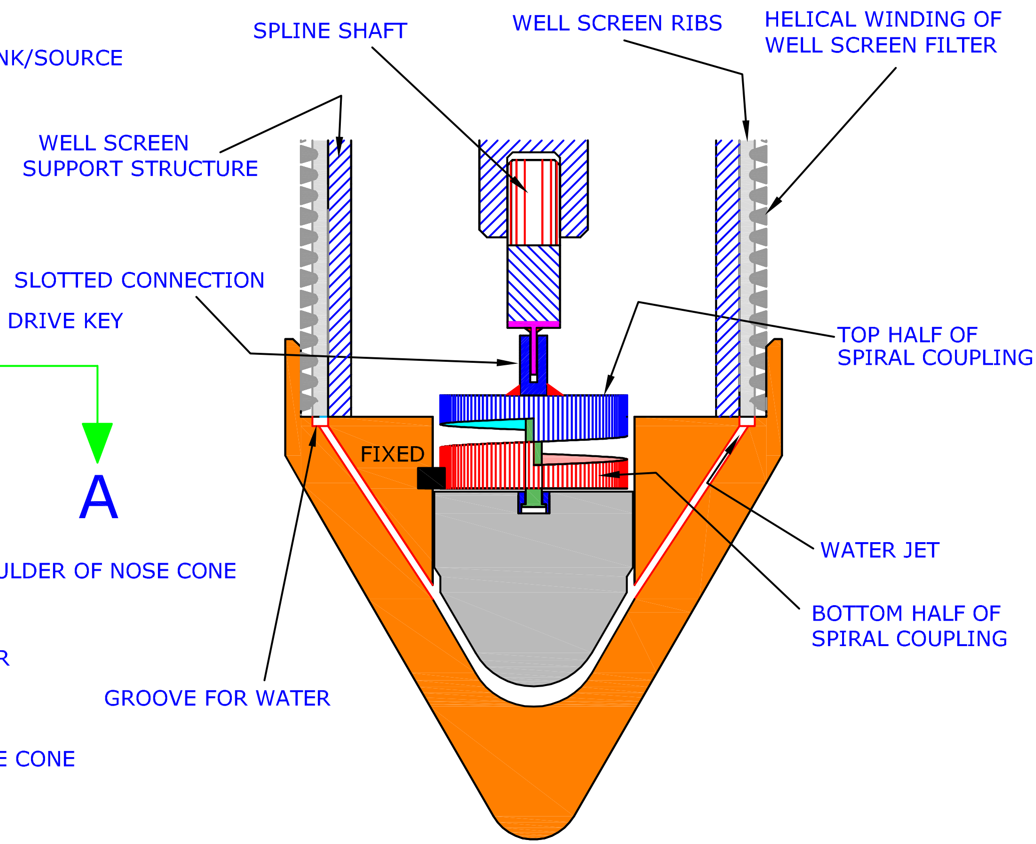
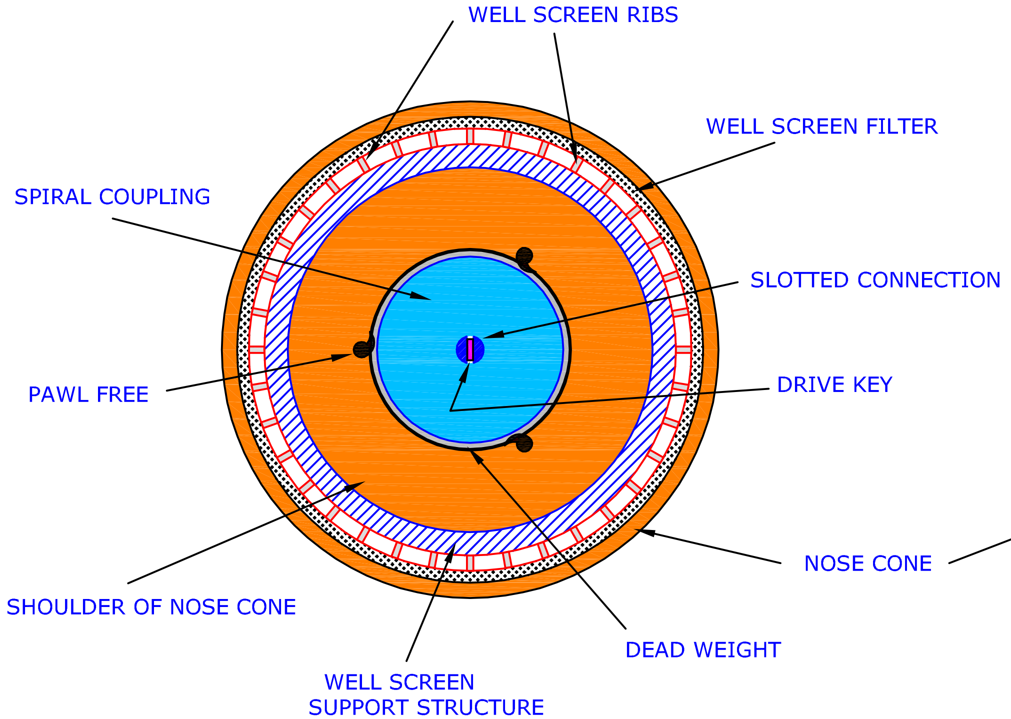


Sketch 1

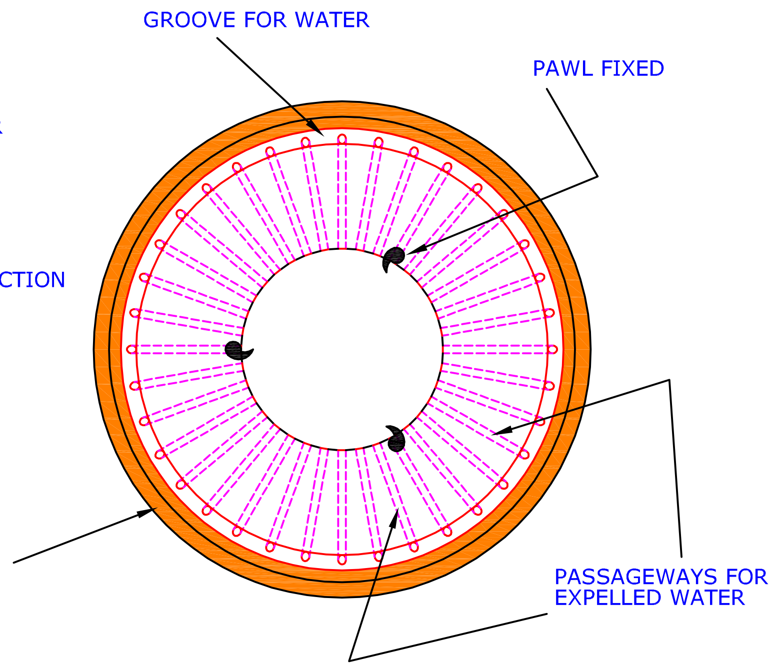


Sketch 2

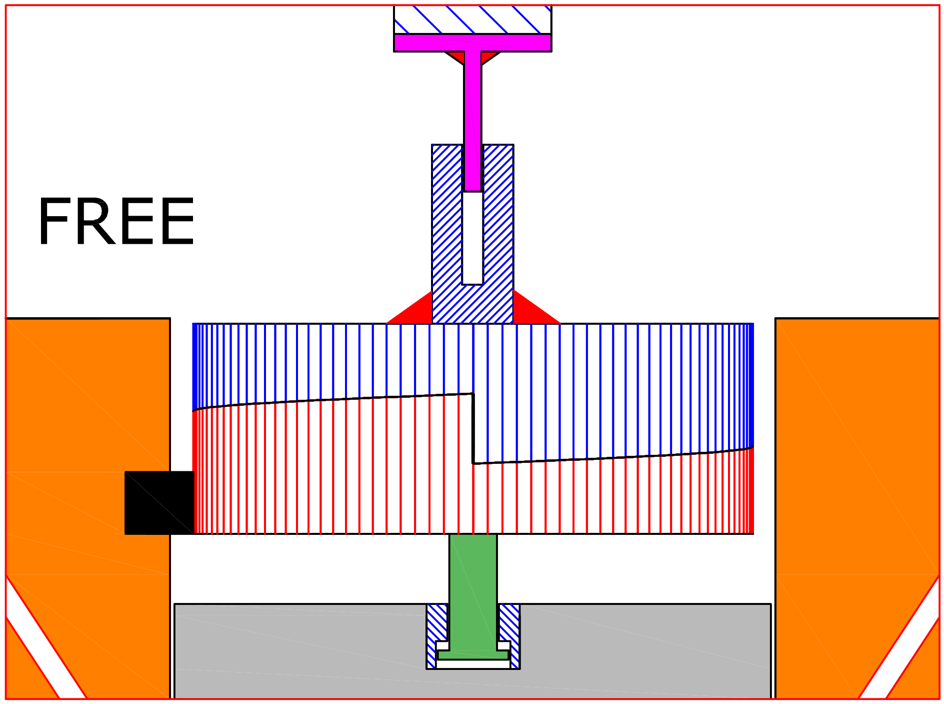
Sections A-A



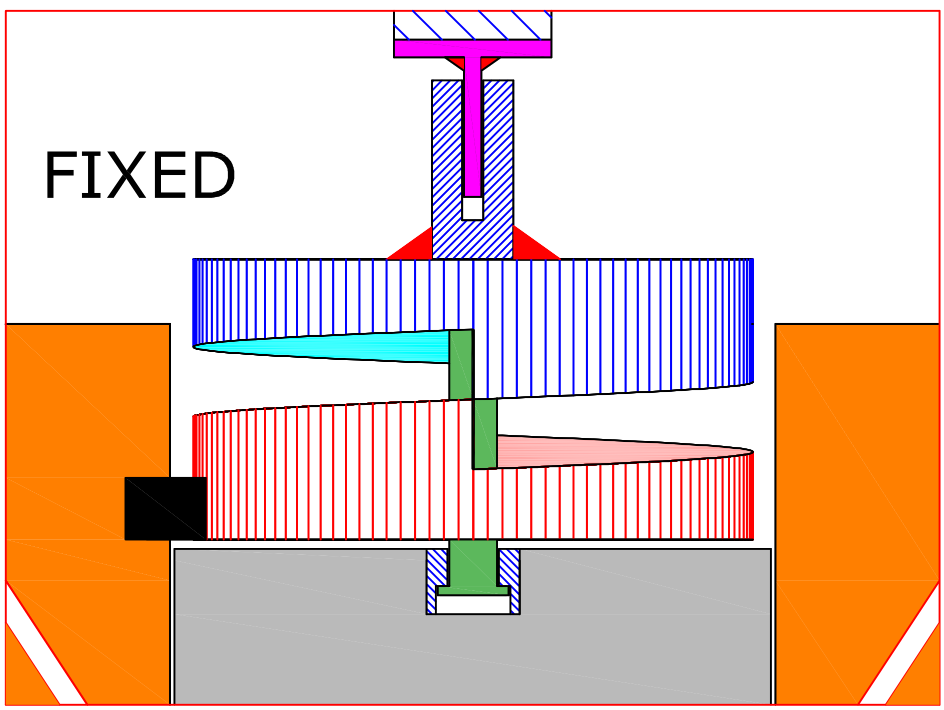
Sketch 3



Sketch 4



Sketch 5



Sketch 6