WE Hodge IP Package Jan 2022

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Included within this Intellectual Property package are four US patents which are related to densification/compaction of particulate matter, that is, geotechnical materials such as mine tailings on the one hand, and on the other dry bulk commodities such as grain, iron ore, and coal. These two radically different material types are now discussed separately under the headings "wet" and "dry" :

Wet

The particular equipment involved in the improvement of water-saturated soils has been called the Phoenix™ Machine [PM]. The first photograph shows the original apparatus built for the remediation of Gulf Resources' offshore Arctic drilling platform (the Molikpaq) where it proved effective to depths of 15m bgl.

For details see Phoenix-Hodge website at this link.

Elsewhere, this machine showed itself capable of transforming the engineering characteristics of weak and compressible saturated tailings slurry into a stable structure which thereafter displayed strongly dilatant behaviour to the full treatment depth of 18m bgl.

For details see Phoenix-Hodge website at this link.

The second photograph shows the current version which has evolved over the years. It is more compact but has the same power and better seepage control than the original design. The next prototype (US Patent 10,240,314) will include a significant geotechnical enhancement; shop drawings have been prepared but, to date, it has not been built.

Accessory hardware parts required for various power drive options and casing extensions are available as AutoCAD © drawing files.

The "Trident" configuration, as defined in US Patent 8,419,316, is formed when three separate PM strings are deployed in parallel and in the triangular formation depicted in *Phoenix-Hodge website at this link.*

Some additional functionality may be attributed to this multiple array of PMs such as: the ability to form very dense vertical sand columns under water; to remove contaminated water from within their compass; and to treat all of large and irregular site geometries in about a third of the time of a single poker.

Hodge believes that, because of its inwardly directed negative hydraulic gradient, the PM is the only method and apparatus capable of stabilizing a tailings dam once it has weakened to the stage of exhibiting surficial signs of approached slope failure.

Dry

The complimentary concept to the above is one of minimizing the space occupied by collections of small dry particles immersed in air. This requires different equipment design but utilizes the same physical principles as the "Wet" case. This concept is secured by US Patent 10,696,502 (issued June 30, 2020).

It has been established in laboratory model testing and in field trials that individual small particles can be brought into closer contact with one another by subjecting the area in which they reside to a combination of vibrational energy, together with simultaneous seepage forces created by appropriate circulation of the fluid phase.

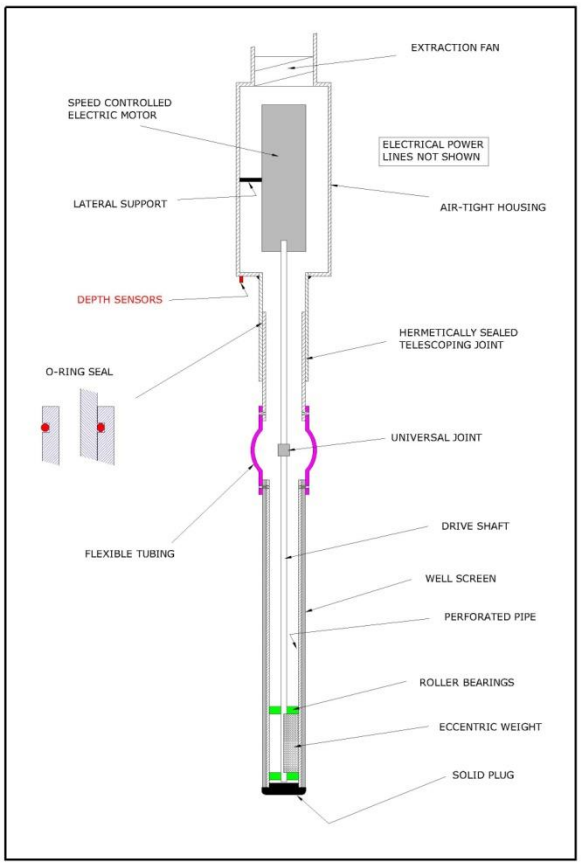
When this novel technique is applied to dry particles contained in air it becomes clear that there is an obvious commercial benefit to be gained by using this idea to maximize the amount of payload that could be fitted into transport vessels.

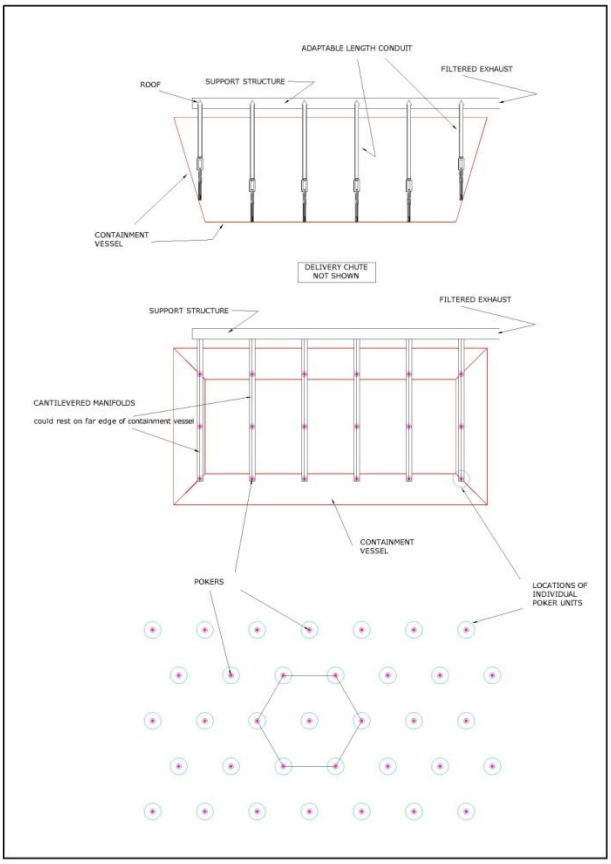
The following sketch shows a design for the apparatus/poker required to produce the agitation/vibration while also acting as the seepage force intake. To give some idea as to the size of this instrument, it is supposed at this juncture that the diameter of its lower cylinder would be about 50mm (2inch).

The fact that some bulk dry commodities are organic, makes it necessary to proceed in a manner that will not cause damage to fragile cargo such as some seeds and berries, while they are being subjected to the vibrational energy needed to encourages compaction. In order to satisfy this criterion, it has been decided that it is necessary to carry out compaction simultaneously with the filling process and to distribute pokers in an array, rather than to employ a few isolated powerful vibrating units.

Since the level of force required to shuffle about individual particles is proportional to the vertical pressure at any depth within the mass it is beneficial to set the pokers in motion just as soon as they are covered with particles, and then to continually raise the pokers as

the surface of the payload increases in elevation, thereby always keeping the overburden weight at the very minimum. This is readily achieved here because of a depth sensor being implanted in each poker. In fact, these sensors make it possible to fully automate the operation of timely withdrawal of the strings, so that there is no need for human supervision in this regard.





The last sketch suggests how a medium sized vessel such as a railway wagon might be filled with compacted bulk dry particulate cargo in this manner.

A prerequisite for implementing this novel system is that the top of the container must be temporarily fully open. This condition is easily met in the case of the hold of a ship which is subsequently protected from rain and wind once the hatch covers are put back in place. But it can be a problem for open-access rail wagons which usually do not come with means to cover loads. In the case of container traffic, it would just be a matter of standing the container on its locked back doors and filling it while its long axis was vertical; then striking off the top and closing the front doors before setting it back on its bomb cart.

On the basis of experience gained in the field during the exploration of the “Wet” aspect of this innovation we anticipate that it will be possible to reduce the space occupied by an amount of small dry particles by about 15% to 20%, thereby allowing that much more empty/unoccupied space into which additional payload can be placed. The reduces fuel transportation cost per ton of cargo would be obviously environmentally beneficial.

For each bulk commodity of interest, laboratory model testing will be required to ascertain what is the vibration frequency it responds to best, as well as the optimal spacing of the poker array. The required apparatus and procedures for such testing has been worked out in detail. The National Research Council were keen to take on this program in their Ottawa laboratories only lacking the federal grant to do so.

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