PROVISIONAL APPLICATION FOR:

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METHOD AND APPARATUS TO REDUCE VOLUME OCCUPIED BY DRY PARTICULATE COMMODITIES DURING TRANSPORTATION OR STORAGE

The apparatus and method described herein are believed to constitute a substantial potential benefit to those involved in the transportation of commodities such as wheat, rice, corn kernels, pulverized coal, and the like: Goods which are conveyed dry and in bulk.

Method Currently Being Used

To the best of the author's knowledge the current method of filling freight containers with dry bulk commodities is to simply pour them into the vessel from an overhead chute without any further attempt to compact them into a smaller volume.

Improvements Proposed Herein

When a quantity of discrete dry particles are pluviated into a receptacle they come to rest as an aggregation whose density of packing is generally quite loose. It has been found that applying vibrations to such a mass results in a decrease in the volume originally occupied, in other words, in densification. This is simply the result of adjacent particles being shuffled closer together.

It has been shown elsewhere (Hodge US 6,554,543) that in the case of a water saturated 2-phased system, that is, wet particles submerged in water, packing density can be improved beyond what is attainable by vibration alone, by simultaneously applying seepage forces to the material surrounding the source of vibration. As a result of that discovery it is now believed that a similar result could be brought about by applying a vacuum/suction to a dry particulate mass.

In consequence of this reasoning it is believed that the concurrent application of vibratory deformation and extraction of air from the void spaces between the discrete particles will result in the dry solids adopting a closer packing and a consequent reduction of the volumetric space need to contain a particular weight of payload.

It should be emphasised that the benefits claimed here for dry commodities are not available to moist materials since in the case of 3-phase aggregations (solid, liquid, gas), the cohesive forces concomitant with menisci formation would greatly reduce the benefits of vibration and overpower the benefits of seepage forces.

It is also necessary to acknowledge that the optimal vibration parameters (frequency and amplitude), and perhaps the degree of atmospheric pressure diminution, are not known at this time for any of the commodities of interest. Additionally, the optimal separation between the individual pokers in plan is currently unknown but expected to depend on the physical/mechanical characteristics of the particles themselves. In consequence, a considerable amount of research will be needed prior to implementation of this novelty.

Explanation/Justification of Method

The functional part of the poker designed for insertion into the empty freight container consists of two separate mechanism which are intended to be activated in unison. The lowermost of these is an axially eccentric weight which produces predominantly lateral vibrations when caused to rotate about its vertical axis. Above this an extractor fan is mounted so as to cause air to be suctioned out from below. Details of various parts of the apparatus are discussed later.

The combined effect of the simultaneous activation of these two elements is to reshuffle the aggregation of the particulate mass while at the same time the aggregation/volume surrounding the poker is subjected to an air flow through the body of the payload towards the source of emanation of the deformations caused by the vibrations.

The physical concept underscoring this novel treatment of a dry particulate mass in order to cause it to assume a tighter arrangement/aggregation is that since the particles reside in the Earth's gravitational field there will be a natural tendency for individual particles to find their way to a lower level/potential when they are jostled about, in other words, it is likely a particle while being displaced horizontally by the vibrations that they will have a tendency to fall into the space between particles in the layers beneath, thereby assuming a higher density of packing. It is believed that this natural tendency will be further enhanced by the fact that such ongoing readjustments of the reconfiguration of the aggregation will be taking place in the draught/current of air flow being brought about by the suctional field/flux produced by the extractor fan inside the poker.

It is believed the best way to affect the packing density of the commodity is while the vibrating screen section is just below the surface of the ever-growing mound of deposition.

The extent to which the beneficial influence of the activated pokers affects the payload peters out as the radial distance from the poker axis increases. Consequently, in order to treat an area larger that the effective compass of a single poker it will be necessary to deploy an array of pokers spread out horizontally so that the full area of interest is adequately affected/treated. Two regular geometrically shaped arrays are discussed later. Also, depending on the physical characteristics of the payload particles themselves, the spacing between pokers forming the array will differ from, say, pulverized coal to corn kernels.

Detailed Description of Apparatus

The apparatus shown in the attached sketches consists of an elongated composite tool, hereinafter called a “poker”. The poker would be activated within the dry particulate mass commodity, hereinafter called the “payload”, in order to encourage/force the individual particles to adopt a closer packing arrangement. The active elements of the apparatus are a vibrator and a extractor fan.

Sketch 1 shows the poker in elevation with the component parts labelled.

Sketch 2 shows two sections in plan, where for the purposes of clarity the lower section “A” has been magnified by a factor of 5 (five).

The poker is comprised of several right cylindrical components fitted together either concentrically with respect to the vertical axis, or placed one atop another. The one exception to this is the weight which is deliberately made eccentric so that it produces lateral vibrations when made to rotate about the vertical axis.

The following is a description of the principal components of the apparatus, in order from the bottom up, and with reference to the Sketch 1:

a. The bottommost item is a blank plug. Its purpose is to prevent external material from entering into the body of the poker. It is made from mild steel (or similar strong metal) and is attached to the poker by screw thread connection/joint so as to facilitate easy access to the vibrator for maintenance.

b. The intimately adjoined pair of tubes to which the end plug is screwed consist of an inner perforated steel pipe to which the outer conduit, a stainless steel well screen, is pre-bonded. An off-the-shelf instance of this piping is the stainless steel Johnson “pipe based” well screen. The function of this pairing is to provide access of the air outside the poker (from the commodity side) to the annular space within the poker by means of the porous openings in this arrangement of conduits. It is the function of the outer well screen to prevent particles of the payload from entering the system while at the same time providing easy entry for the air from within the voids spaces of the commodity.

c. Close to the bottom of the well screen, and secured thereto, is the vibrator. It consists of a half cylinder of metal attached to a drive shaft. The half cylinder is of the shape derived by cutting a right cylinder in two equal parts along the central vertical axis. The drive shaft is held central to the poker axis with roller bearings at either end of the eccentric weight. The bearings are themselves held within metal housings which are fixed in place vertically by retaining rings anchored in groves cut into the inner perforated pipe.

d. The drive shaft is aligned with the poker's axis up to a level above the top of the well screen. There it mates with a universal joint so as to allow for some degree of non-vertical oscillation of the shaft below.

e. Surrounding the universal joint, and forming the outer conduit of the poker hereabouts, is a bulbous conduit made from a flexible fabric such as reinforced rubber-type material. This length of conduit is fixed to the rigid steel pipes (metal conduits) above and below with fasteners such as pipe clamps. The function of this section is to permit for lateral angular straining of the lower part of the poker with respect to the upper.

f. In order to facilitate minor adjustments to the active length of the poker unit an extendible section of conduit has been incorporated between the flexible section and the motor drive housing. This is achieved by providing for two metal pipes to be telescoped, one within the other. Since this resides within that part of the poker where suction is to be maintained, a hermetic seal is provided between the two pipes. The design of this seal is shown as a magnified (by 5) insert on the left side of Sketch 1. It consists of an elastic o-ring which is purposely chosen to be slightly oversized for the separation available between the two pipes. It is set in a grove near the top of the inner pipe so that it is forced to make pressure contact with the outer pipe. This arrangement is not novel and has been found effective.

g. Above the universal joint the drive rod extends to the an electrical motor providing rotational motion which is aligned coaxially with the poker. The motor is held securely within its housing by radial struts. The couplings between the drive rods, the eccentric weight, the universal joint, and the power motor are of the male/female spline type because such couplings can accommodate some amount of axial movement without loss of torsional transmission.

h. The power motor will require a means of speed control such as gearing in order to provide the particular rate of rotational vibration found optimal for the type of commodity being treated on any occasion.

i. Remote sensing devices, such as depth/distance measuring instruments, are attached to the underside of the motor housing. Their purpose is to determine two things: The position of the plugged end of the poker with respect to the bottom of the containment vessel floor; and also where the top of the payload is with respect to the top of the well screen at all stages during commodity loading.

j. The uppermost functional element of the poker is a full-throat suction, or extractor fan housed in a cylindrical section. Its purpose is to maintain sub-atmospheric pressures within the poker while it is active.

k. Above the poker, and connecting the air exhaust from individual pokers to structure supporting the array, (see Sketch 3) a conduit of readily adaptable length is considered a desirable environmental ancillary. While it is not functionally necessary for the ductwork above the fan to be hermetically sealed, it is nevertheless desirable for the sake of avoiding swamping the local air with chaff, that the great majority of the outlet from the pokers be controlled and contained within a filtered exhaust ductwork. Two designs for adaptable length discharge conduits are shown in Sketch 4: One shows a concertina-type conduit; the other a nest of telescoped circular pipes.

l. In order to keep this adaptable length taut two opposing mechanisms are build into this conduit: a coil/helical spring under compression and a drum hoist whose cable is in tension. Both the spring and the cable are placed such that their long axis is concentric with the conduit and extend between the fan mounting on up to the exhaust outlet level of the cantilever support structure. The passive state of the spring is compression, whereas that of the cable is tension. This conflict of parallel forces makes it possible to accommodate the optimum elevation at which the poker resides within the vessel, while at the same time, insuring the verticality and concentricity of the this conduit of variable length. Thereby the position of the poker is dictated by the length of cable which the drum hoist reels out. The hoist's activity is in turn controlled by signals coming from the depth/distance sensors.

m. It is anticipated that the cantilevers and their support structure will formed out of mild steel or aluminium, in which case the detailed geometry of the assemblage is a simple matter of structural design involving no novelty. The design criterion will be to minimize the loss of flow area available to the chute. Consequently, the beams which support the string of separate pokers, need to be slender in plan, with roofs steeply pitched ("snow-shedding" A-frame type), rather than presenting flat surfaces on which the commodity might lodge. And, although these manifolds are shown as cantilevered, it is obvious that these beams could be made to rest on the vessel wall on the far from the support structure itself.

n. The series of manifolds will in turn be supported, and held in position, by a horizontal beam standing at a convenient height with respect to the top of the containment vessel. If this beam were of hollow section it could serve two useful purposes: It might contain a filtering system to rid the air exhaust of dust before releasing it back to the atmosphere; and, with the incorporation of a large ventilation fan at the structural outlet would minimize backpressure on the individual poker fans.

Method of Operating/Utilization of Apparatus

Sketch 3 suggests two different arrays in which a plurality of pokers could be deployed as a single assembly for the purpose of treating a mass of loose payload. The upper depiction shows how this multi-unit apparatus might be lowered into a relatively small freight container such as a railway wagon. The bottom diagram of Sketch 3 is a depiction of a hexagonal array, the bee-hive cell shape, a configuration which might better suit larger volumes such as ships' holds. It is further contemplated that this apparatus might advantageously be fixed to the chute delivering the payload to the container.

The goal in deployment of these tools is to avoid interfering with the normal filling rate of the vessel and also to limit any complication to established procedures as far as possible. For that reason it is conceived that the individual pokers would be (as shown in the diagram) fixed to structurally competent cantilevered manifolds so that all the pokers could be deployed in one motion.

Prior to deployment the gearing (speed control) of the electric motors would be set to cause rotation of the eccentric weight at the optimal rate applicable to the commodity to be loaded.

As soon as the containment vessel arrived in position beneath the commodity chute the poker array support structure would be lowered/rotated into it.

Immediately thereafter the hoist cables, on the basis of sensor readings, would be activated so as to set the length of the adjustable conduit so as to seat the end plug just above the floor of the vessel at each of their pre-designated positions.

Electrical power would be made available to the apparatus as soon as loading commenced but power to the individual pokers would not be switched on until the depth sensor of a particular poker indicated that the payload material had covered the top of the well screen. This is to avoid swamping the air extraction capacity of the manifolds.

As loading progressed, and various well screens became submerged beneath the particulate mass such pokers would receive power and both its vibrator and the fan turned on. Shortly thereafter the cable winch would begin to withdraw the poker towards the top of the vessel so as to apply the vibratory and air suction most effectively, that is, close beneath the surface of the loose mass. In other words, each pokers would be individually raised to keep pace with containment filling at each of their separate locations.

It is obvious that because the functional elements of the apparatus are all driven by electrical power, and their activity controlled by electronic sensors, this system lends itself to robotization. The computer program required for full automation of the process is a simple matter.

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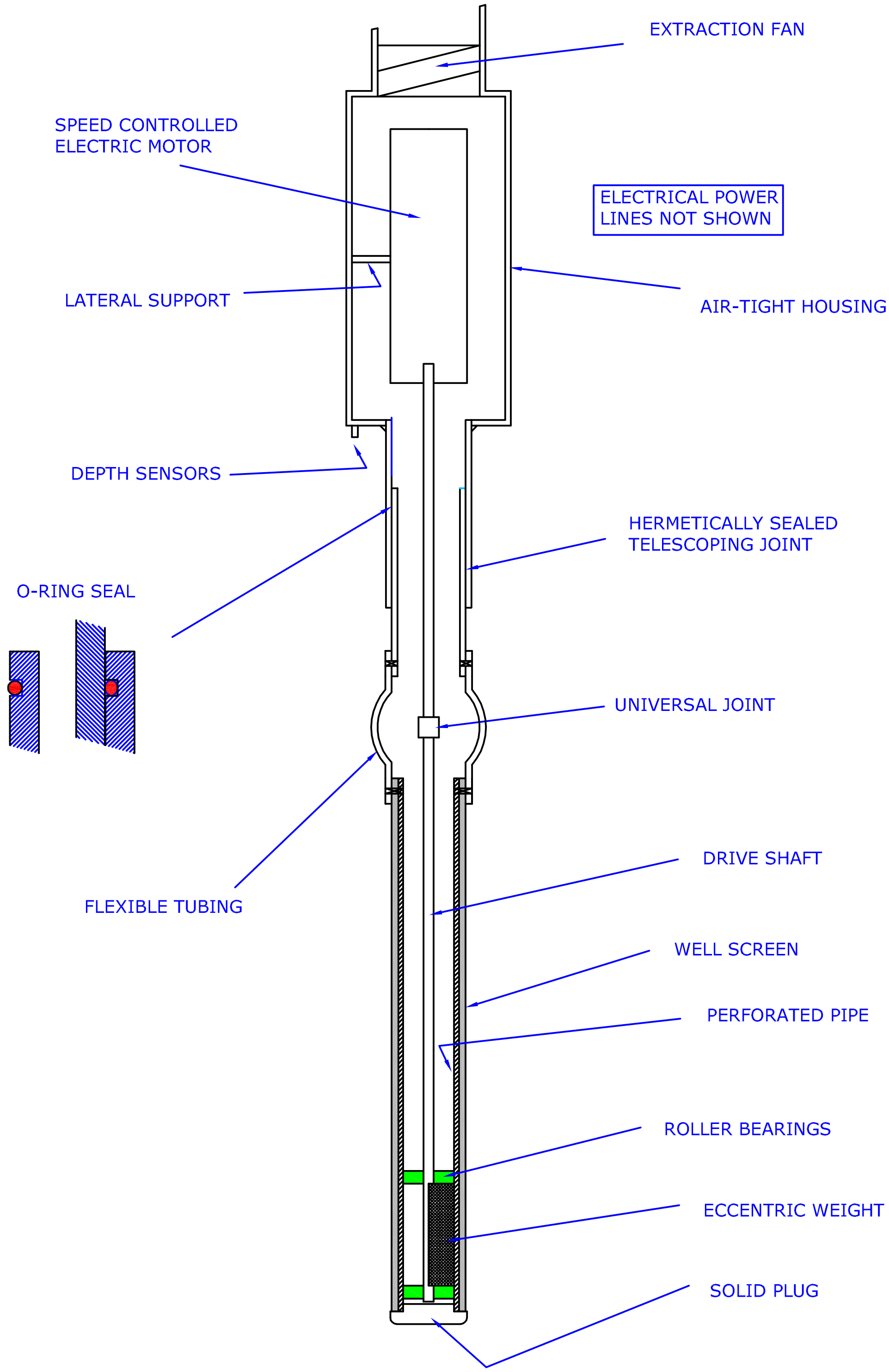
EXTRACTION FAN
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ELECTRIC MOTOR
ELECTRICAL POWER
LINES NOT SHOWN
LATERAL SUPPORT
AIR-TIGHT HOUSING
DEPTH SENSORS
HERMETICALLY SEALED
TELESCOPING JOINT
O-RING SEAL
UNIVERSAL JOINT
DRIVE SHAFT
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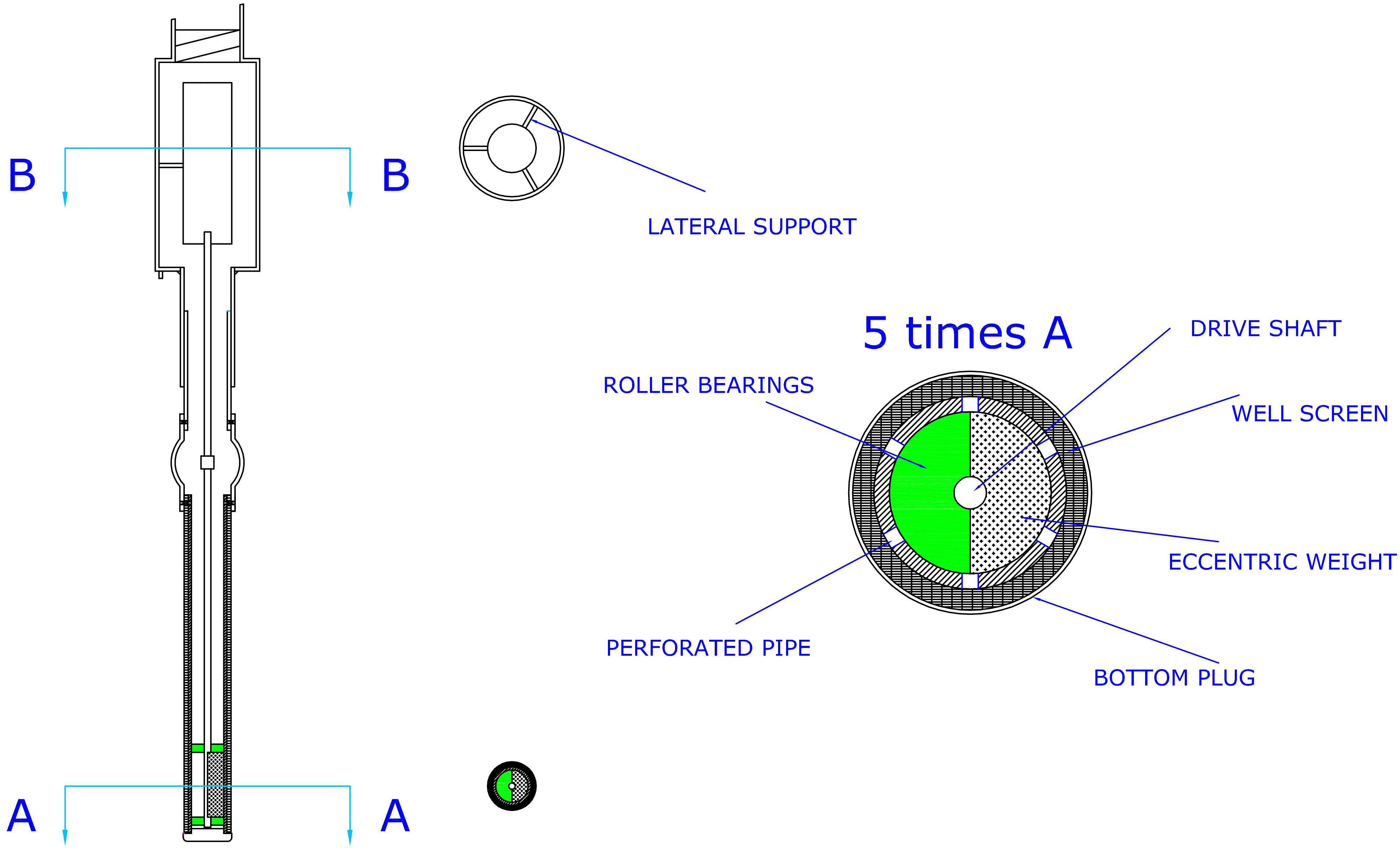
WELL SCREEN
PERFORATED PIPE
ROLLER BEARINGS
ECCENTRIC WEIGHT
SOLID PLUG

Sketch 1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LATERAL SUPPORT
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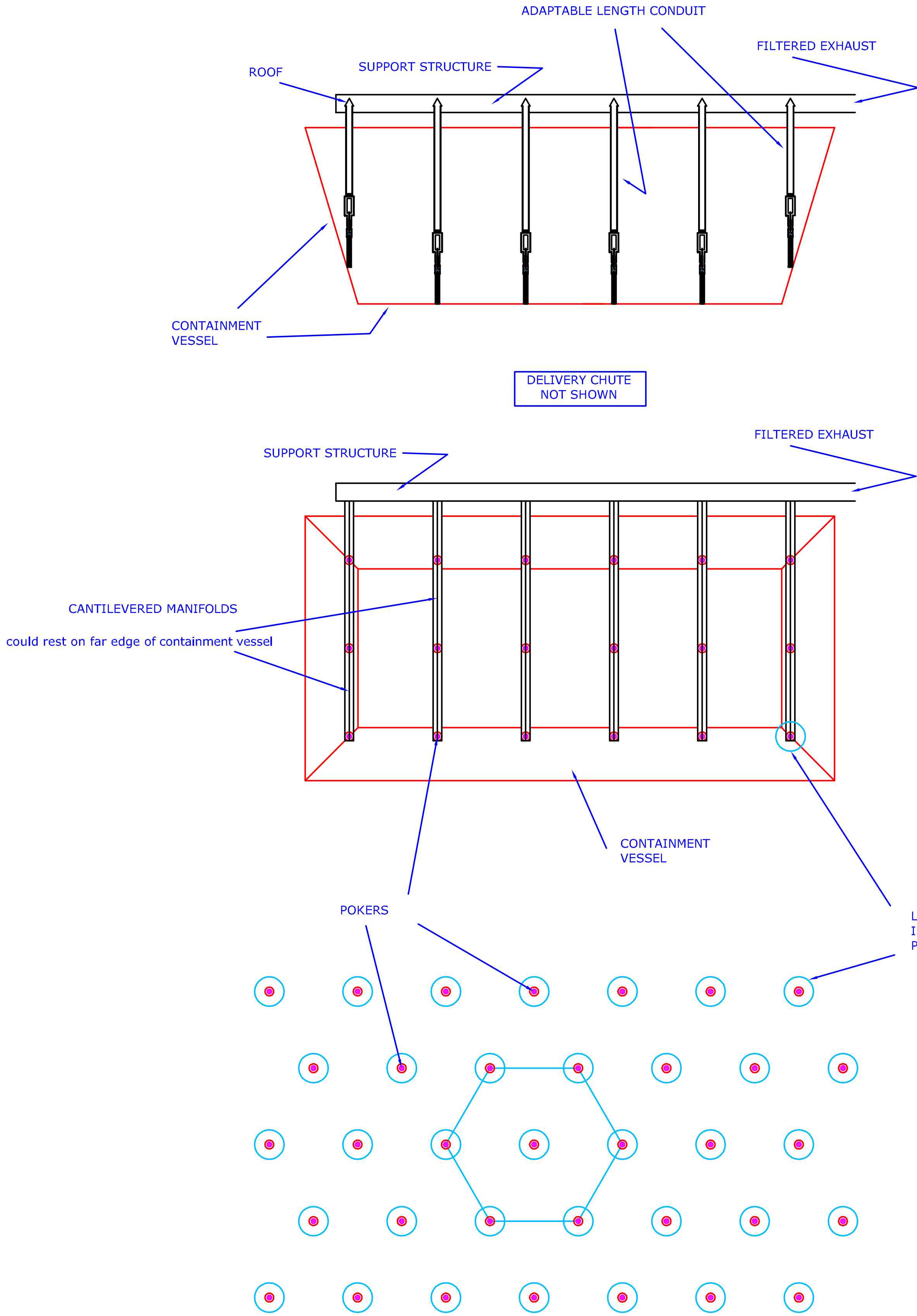
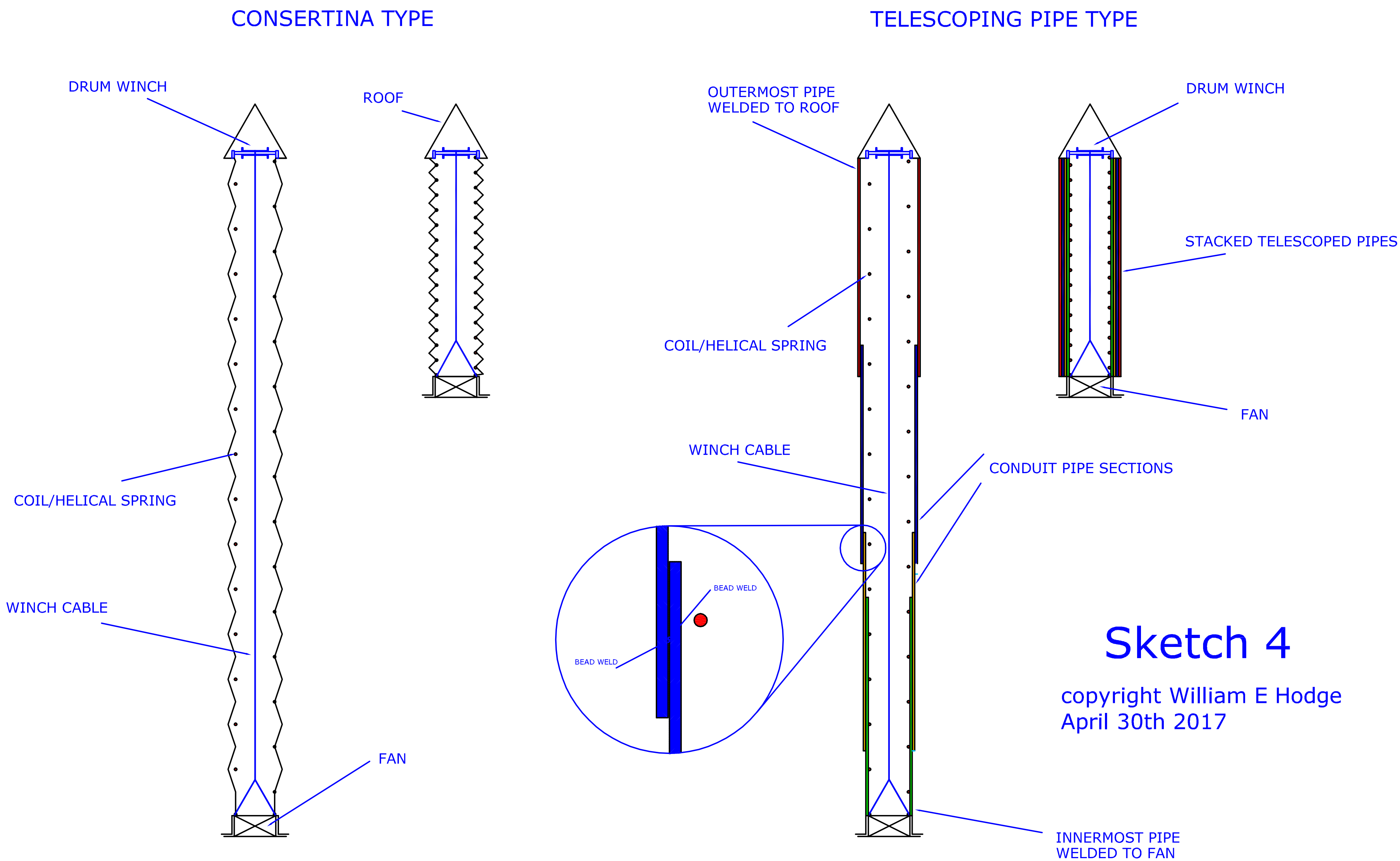
Sketch 2


ADAPTABLE LENGTH CONDUIT
FILTERED EXHAUST
ROOF
SUPPORT STRUCTURE
CONTAINMENT VESSEL
DELIVERY CHUTE NOT SHOWN
SUPPORT STRUCTURE
FILTERED EXHAUST
CANTILEVERED MANIFOLDS
could rest on far edge of containment vessel
CONTAINMENT VESSEL
POKERS
LOCATIONS OF INDIVIDUAL POKER UNITS

Sketch 3

ADAPTABLE LENGTH CONDUITS



Sketch 4