Visual Circulation

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What is Visual Circulation

Visual Circulation is a term I have coined to describe the actual visual observation of dissolved oxygen in water at varying points during the operation of fountains, surface aerators, small bubble aerators, and big bubble circulation pumps.

Properties of Visual Water

The density of water increases as the temperature decreases and decreases as the temperature increases. This allows seeing the movement between different states of water possible. If ice water is poured into a clean glass of warm water, you will observe these phenomena. Bubbles that lift colder and heavier water that are produced by equipment situated on the bottom of the lake eventually mound at the surface. After mounding, this colder heavier water that moves outward across the surface is seen as visual waves which eventually slow and sink back into the lake.

Temperature also affects the oxygen carrying capacity of water. As the water cools it can hold more oxygen per pound of water. The coolest, most dense liquid water resides at the bottom of the lake where oxygen has usually been depleted by decaying matter. This lower temperature, lower oxygen, denser water from the bottom of the lake can absorb much more dissolved oxygen per gallon when exposed to the atmosphere than any other water in the lake.

Hot Windless Summer Days

Water in lakes on windless days form a film on the surface that allows light to pass straight through while inhibiting free gas flow and heat transfer between the atmosphere and the lakes water (figure 3). This film is formed by a combination of water molecules bonding with oils from decaying organic material and dust from the air. If this film is not disturbed by wind forming ripples or artificial means, it will thicken while light penetrates deeper into the upper surface layer. This stimulates phytoplankton to grow quickly. This growth of phytoplankton eventually blocks the sunlight causing plant growth to stop. The now dying plants then decompose using the last of the oxygen. The result is anaerobic algae growth.

During the evenings on windless summer nights (figures 3 & 4), the lake cannot release the heat and gases built up during the day because of the previously noted layer of film. The heat and other gases including nitrogen then stimulate faster algae growth.

The growing algae layer will eventually cover the lake's surface and become a smelly nesting ground for mosquitoes and other insects.

Ripples

Water molecules move up and down forming ripples when the surface layer is moved by a constant wind blowing across the top layer of water. Falling objects such as rocks, water droplets, or rising air bubbles will also form ripples. The water molecules in the lakes surface form ripples in relation to the winds drag or the energy of an object breaking through layers of water. In addition, the constant drag from winds on an object disturbing the surface provides the potential energy to form ripples (figures 1 & 2) that move away from where the surface was disturbed in evenly spaced straight lines or circular patterns. The bottom line is that the greater the energy resulting from disturbances breaking the surface, the bigger and farther the ripples move from the source of the energy. Because the leading edge of a ripple moves slower than the trailing edge, the ripple's height is raised. This action thins the film layer which allows gas and heat to pass through the lake's surface.

Because these ripples diffract the sunlight as it enters the surface, the light rays don't penetrate as deeply into the lake. This result prevents the overgrowth of phytoplankton, duckweed, and other plants. Insects additionally, don't land to lay eggs on moving water.

Electric Pump Based Systems

Fountains (figures 5 & 6) and surface aerators (figures 7 & 8) use electric pumps under the main floating body to generate the water pressure required to lift and spray hundreds of gallons of water into the air each minute. Most electric pumps run on 110 volt or 220 volt AC which can be a shock hazard in water if the power wires become exposed. Fountains must be located within a hundred feet of the power source due to electrical resistance through the wires.

Fountains

Most fountains (figure 6) consist of a floating platform anchored to the bottom with weights attached to the fountain. The floating platform supports a submerged electric well pump that supplies the pressurized water to the piping and nozzles that form the spray pattern.

When the power is switched on, lake water is drawn into the spinning pump impellors and increases in pressure, flow, and temperature. This pressurized water feeds a piping system which creates the flows required for the spray patterns to form as the fountain operates. What is seen by the naked eye as a stream of water is actually millions of various size droplets flying through the air. Droplets may evaporate as they fly through the air. This cools the entire area under the fountain by as much as 10 degrees or more. The remaining majority of the droplets cool, increase in density, and absorb oxygen before falling back onto the lake's surface water.

The size and temperature of the droplet as it penetrates the surface will determine the quantity of oxygen and amount of energy being absorbed by ripples. Larger droplets will punch through the surface and go deeper in a limited area creating larger ripples that flow farther from the point of impact. Smaller droplets penetrate the surface forming smaller ripples that move outward only a short distance.

Using Visual Circulation, one can predict where the water will be lower or higher in oxygen. A well-designed fountain for aerating the water will cover the largest surface area as evenly as possible with a mist. The smaller the bubbles, the more surface area for evaporation and oxygen absorption. In comparison, larger droplets have more energy when penetrating the surface and create a larger area with longer lasting ripples. When the distance between the ripples is closer together, this indicates a fountain producing smaller bubbles. A stream with larger bubbles passing through the surface might be visible as turbulence in another part of the fountain by creating visible ripples as the stream's bubbles pop up from below the surface.

The plume of dissolved oxygen in the water around and below the fountain would be from the fountain's center to the edge of the farthest ripples seen on the surface (figure 5). The depth of the dissolved oxygen plume goes from several inches below the surface at the farthest edge of the ripples to a point several feet below the pump's inlet. Looking at the overall fountain, the highest concentration of dissolved oxygen is captured within the area of the coolest droplets passing through the evaporation zone formed by the fountain's spray. This evaporation zone can be 10 degrees cooler than the surrounding air and the droplets will contain more dissolved oxygen. These cooler high oxygen droplets heat up while penetrating the lakes surface and release some dissolved oxygen into the atmosphere. The remaining oxygen is absorbed into the water resulting in higher levels of dissolved oxygen that may extend from the surface to several feet deep. How deep the dissolved oxygen goes below the visible ripples is dependent on the size and speed of the droplets as they enter the water. Bigger more consistent droplets result in larger and longer existing ripples. The optimum solution at this point is to circulate the high oxygen water below the fountain throughout the lake.

Surface Aerators

Surface aerators (figure 8) have a submerged electric motor with a marine propellor mounted inside a cylindrical opening through a floating platform. When the aerator is turned on, the impellor spins drawing lake water through a lower screen into the cylindrical opening and up past the impellor into the air. The impellor aerates and lifts the water 2 or 3 feet into the air before the water falls back into the lake several feet past the edge of the float.

The surface aerator isn't forming smaller bubbles like the fountain. It is moving hundreds of gallons through an impellor that cuts air into the water as it mounds flowing over into the lake. This large volume of air and water will be slightly cooler from the evaporation process but will carry less oxygen per pound than a concentrated area of small bubbles. This heavier volume of cooler water will transfer more potential energy deeper into the lake than small falling bubbles. This heavy volume of water will penetrate slightly deeper than the fountain's bubbles. This small waterfall transfers the potential energy to create a slightly larger rippled area than a similar sized fountain. These larger ripples result in a medium zone of circulation from below the pump to the edge of the ripples.

Using Visual Circulation to design an ideal dissolved oxygen plume for a surface aerator will result in the largest rippled surface area. The dissolved oxygen plume surrounding the aerator goes from about a foot below the pump's center to several inches from the edge of the visible ripples seen on the surface. Larger aerators provide more flow creating a bigger and higher mound. The more expansive the mounding, the larger the rippled area.

The optimum solution at this point is to circulate the dissolved oxygen plume created by the surface aerator throughout the lake.

Compressed Air Systems

Small bubble aeration systems and big bubble circulation pumps use electrical compressors to supply pressurized air for either aeration or for water movement. Compressed air systems can efficiently deliver pressurized air to diffusers or pumps at distances over 1,000 feet. In remote areas, solar power is usable, but more expensive. Also, today's compressed air stations are more efficient, quieter, and easier to install than in the past. Aeration systems generate a multitude of small bubbles via diffuser assemblies to dissolve quickly and aerate the surrounding water. Although many of these bubbles dissolve , a small percentage of them make it to the surface.

Small Bubble Diffuser Systems

Small bubble aeration systems (see Fig. 10) consist of weighted air diffuser assemblies spaced across the bottom of a lake that are supplied with compressed air through weighted air hoses from a shore based air station. Each diffuser assembly consists of one or more round or tubular diffusers that are created from synthetic fabrics that produce small bubbles when pressurized air is supplied to the diffuser assembly's inlet. The bubble size produced by air passing through the synthetic fabric is dependent on not only the pressure of the air pushing from the inside to open the synthetic fabric, but also the pressure of the water on the outside keeping the synthetic fabric closed. The deeper the diffuser assembly is installed in the lake, the smaller the bubbles are produced and the faster they dissolve. Water directly around the diffuser assemblies will be opaque because the dense bubbles block light from passing through. The dissolved oxygen level in the slowly rising columns of bubbles and water will be dependent on the temperature and pressure.

Small bubbles sometimes combine with each other to form slightly larger more buoyant bubbles that will begin rising to the surface. These bubbles increase in size and speed as they rise to the surface following Stokes law. Stokes law states that as bubbles double in size, their upward velocity rises by four. Only a small percentage of the bubbles will make it to the surface while lifting and dragging water. These surviving bubbles create moving ripples that form a visual area. If there is little to no wind the visible rippled area will be a circle. If there is wind that also forms ripples on the lake, the shape of the rippled area will be an ellipse in the direction of the wind (figure 9).

The shape of the dissolved oxygen plume in the lake surrounding the diffuser assemblies from the bottom to the top looks like an upside down glass of wine. Where the liquid would be in the glass is the area highest in dissolved oxygen. The glass's stem represents the rising bubbles combining with other bubbles to form a column of slowly rising saturated water heading to the surface. The bubbles carrying the water that make it to the surface will mound forming the base of the upside down wine glass. If the diffuser assembly is deep enough all the bubbles will dissolve before reaching the surface.

The Visual Circulation for the small bubble aeration system in a lake starts with the location of the bottom diffuser assembly. Mounding and circular ripple movement directly above the diffuser assembly shows the location of the diffuser and the area of surface flow. The water creating the visible ripples is slightly cooler than the surface water because it rose from the colder water surrounding the diffuser assembly to the surface at approximately 1 foot per second. Again, the size and distance traveled by the ripples will be based on the size of the bubbles breaking the surface and the water they carry.

The optimum solution at this point is to circulate the dissolved oxygen plume above and surrounding the diffuser assemblies throughout the lake.

Big Bubble Circulation Pump

The U.S. Patented Big Bubble Circulation Pump is normally installed on the bottom of a lake near the middle of an area around which up to approximately three (3) surface acres can be expected to be circulated. The Big Bubble Circulation Pump runs on the same compressed air as the diffuser-based aeration systems mentioned earlier. When the compressor feeding air to the Big Bubble Circulation Pump is energized, pressurized air enters the Big Bubble Circulation Pump which then forces water vertically out of the top of the pump. As soon as the last of the water exits the pump, the air which is now unimpeded by the exiting water increases the flow by drafting water from a lower pump zone into the bubble chamber. This cycle repeats hundreds of times each minute forming one five-inch bubble after another.

These rising five inch bubbles increase in size and speed while lifting and drafting cold low-oxygen water to the surface. As these five-to-nine-inch bubbles break the surface, the water mounds and flows across the surface absorbing oxygen from the atmosphere and forms traveling ripples from the energy of one large bubble after another crashing through the surface. The energy and water flowing across the surface creates large stable ripple patterns over approximately a three acre surface area. These results were recorded using a ¾ horsepower rocking piston compressor feeding air through ½-inch weighted hose.

The Big Bubble Circulation Pump creates openings through the surface 24/7 in any weather. These ripples create healthier conditions for fish and other invertebrates by thinning the surface film allowing for gases and heat to pass through the film on windless sizzling summer days. The 24/7 ripples additionally diffuse the sunlight from passing deep into the water. This prevents excessive growth of deeper plankton that would eventually block the sunlight.

The Big Bubble Circulation Pump creates a vertical flow that lifts cold low-oxygen water to the surface, mounds, and forms ripples over approximately a three-acre area while continually absorbing oxygen from the atmosphere before sinking back into the lake and naturally flowing back towards the pump. This aforementioned process exemplifies Visual Circulation. A couple of other benefits from installing a Big Bubble Circulation Pump are: (1) Insects don't lay eggs on moving water in the summer and (2) In the winter, there will be a 60 to 80 foot hole in the ice just above the Big Bubble Circulation Pump for fish to respirate and for waterfowl to have a patch of water to land on.

Visual circulation with a Big Bubble Circulation Pump is the easiest of all to evaluate. If you see ripples on the surface, you can be certain that oxygen is being absorbed from the atmosphere before being recirculated back to the pump.

The Ideal System

While each of the systems that have been described are good at performing their function of adding dissolved oxygen to the water, each is at the will of the wind and currents to distribute the dissolved oxygen throughout the lake. Adding a Big Bubble Circulation Pump to any of these technologies would circulate the dissolved oxygen throughout the lake while capturing more oxygen from the atmosphere as ripples of cold low-oxygen water from the bottom of the lake flow across the surface.

I would recommend a Big Bubble Circulation Pump to recover dissolved oxygen from the atmosphere by creating cold water ripples across the surface of a lake. In addition, I would also recommend installing diffuser assemblies on the bottom circling the Big Bubble Circulation Pump at a distance that provides dissolved oxygen across the bottom where organic material decays (figure 13). A portion of dissolved oxygen from the diffuser assemblies will then flow to the Big Bubble Circulation Pump to be added to future circulation.

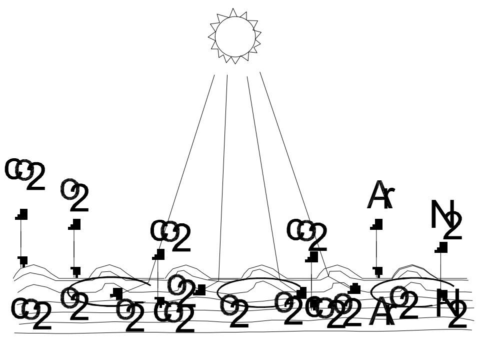


Fig 1

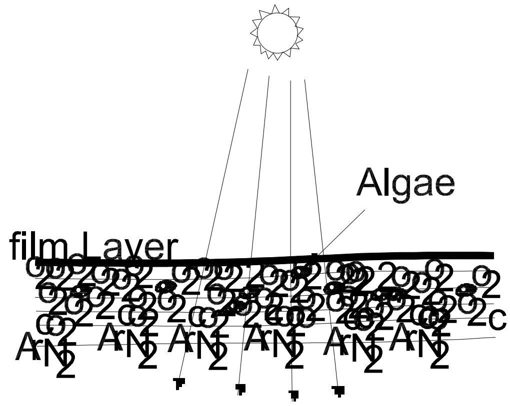
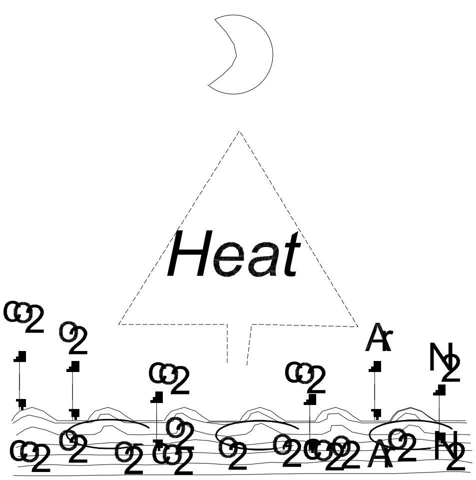


Fig. 2



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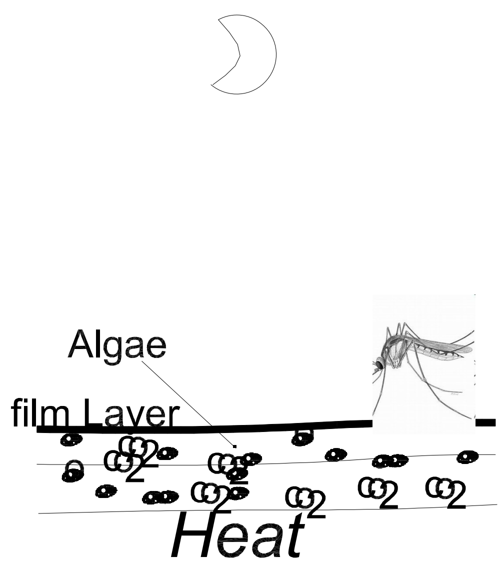

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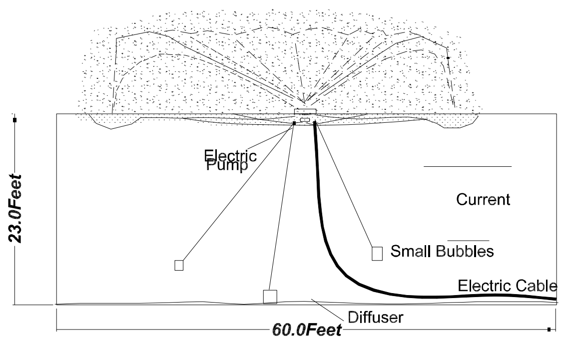

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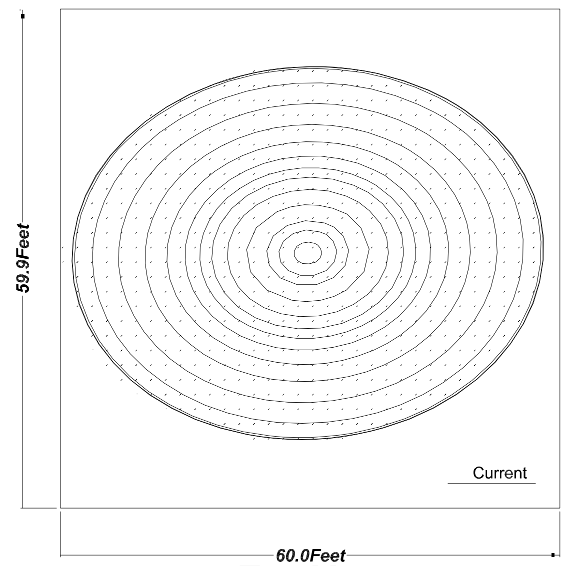
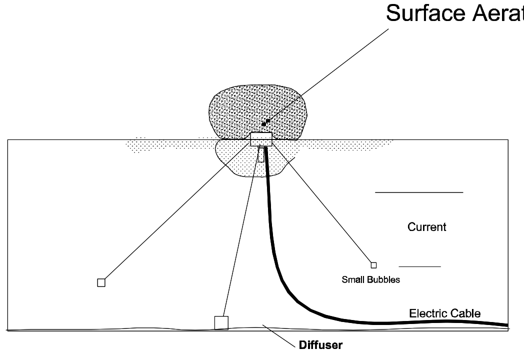


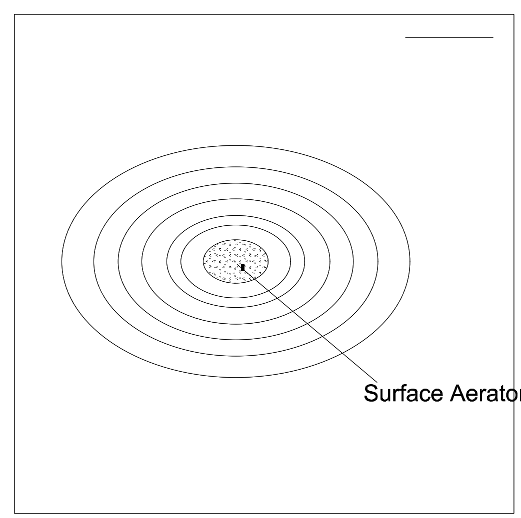
Top View

Fig.5

Fig. 6



Side View



Top View

Fig.7

Fig.8

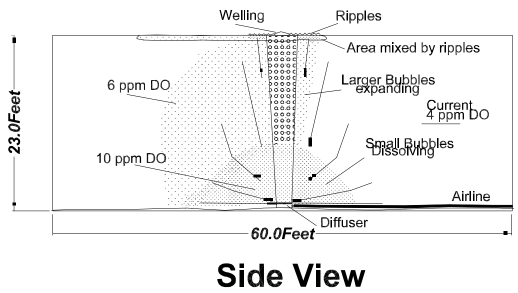


Fig.9

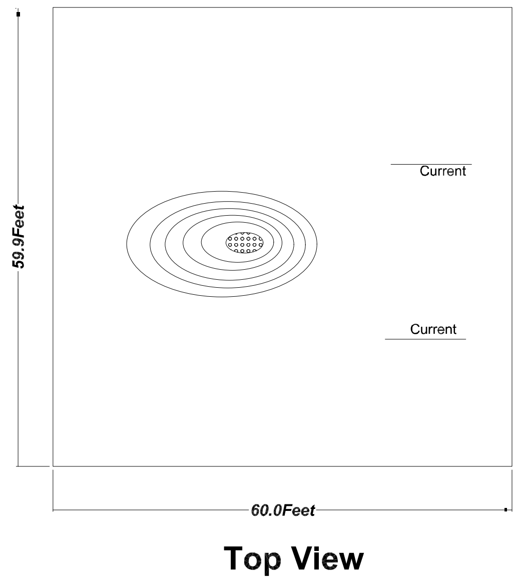


Fig.10

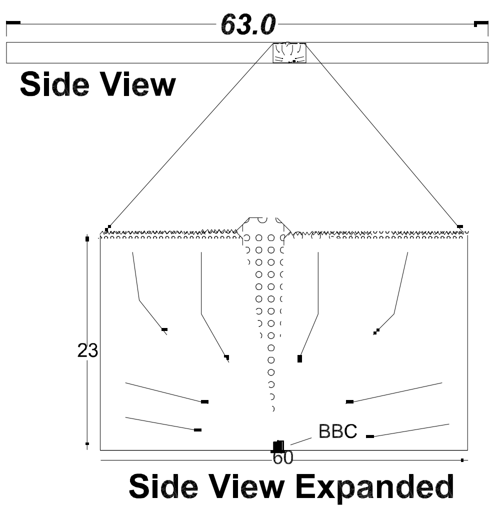


Fig.11

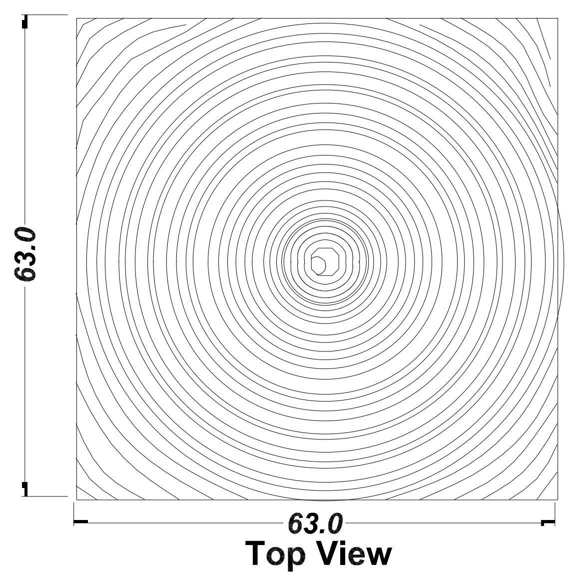


Fig.12

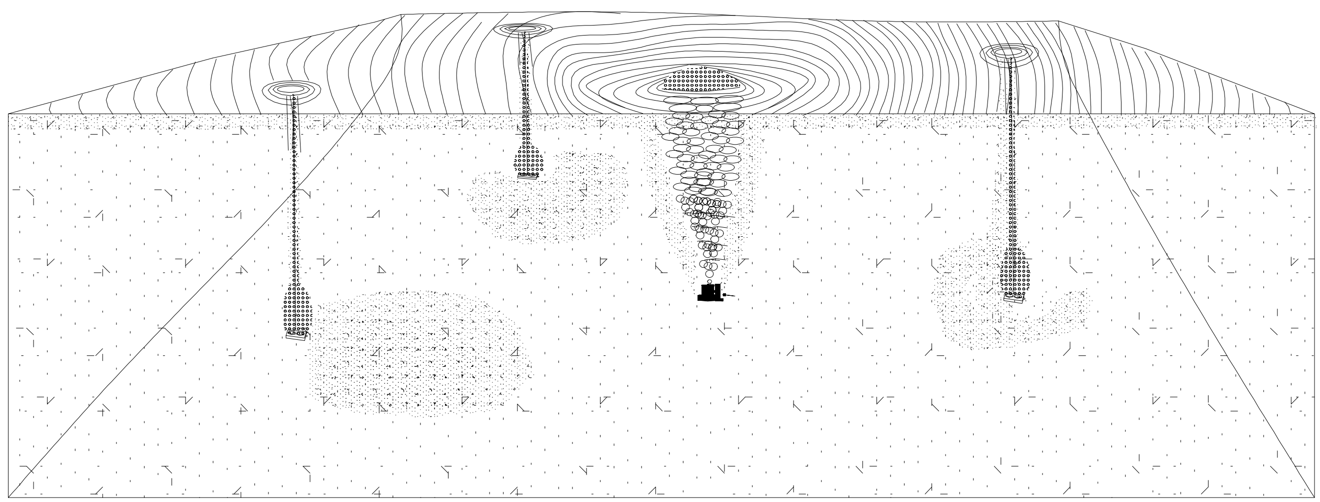


Fig. 13