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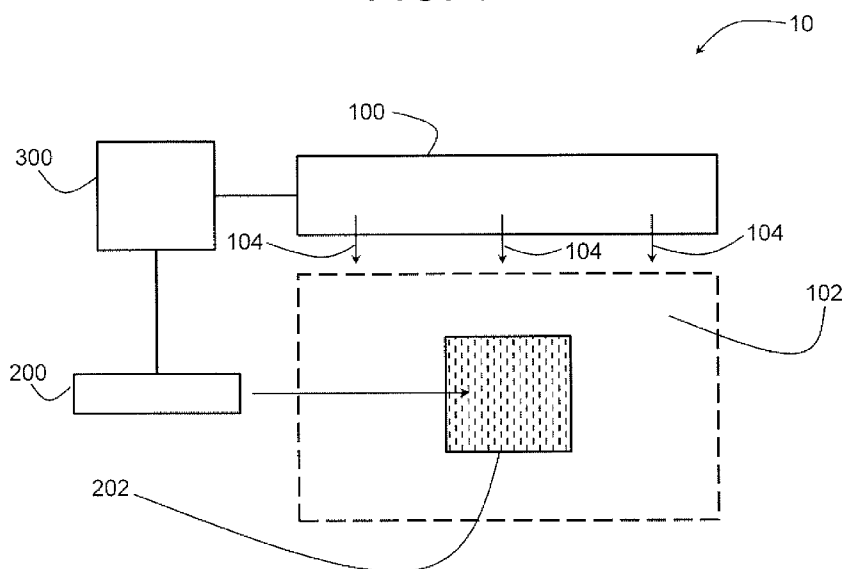
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FIG. 1



(57) Abstract: A system and method for altering the visual appearance of moving physical forms is disclosed. The moving physical forms may include solids, liquids, gasses and any combination thereof. The system and method may include video capturing devices for capturing video footage of the moving forms, a controller for altering the captured video footage of the moving forms, and video projecting devices for projecting the altered video footage back onto the moving forms.



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SYSTEM AND METHOD OF ALTERING THE APPEARANCE OF LIQUID AND SOLID PHYSICAL OBJECTS OR FORMS

Cross-Reference to Related Application

[0001] This application claims the benefit of U.S. Provisional Application No. 62/812,216, filed February 28, 2019, the contents of which are incorporated herein by reference.

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[0002] This patent document contains material subject to copyright protection. The copyright owner has no objection to the reproduction of this patent document or any related materials in the files of the United States Patent and Trademark Office, but otherwise reserves all copyrights whatsoever.

Field of the Invention

[0003] The current invention generally relates to a system and method of altering the appearance of liquid and solid physical objects, including altering the appearance of moving liquids and solids through the use of projected video, optics and optical techniques.

Background of the Invention

[0004] Moving objects or forms have been used in displays and as forms of entertainment for many years. And, whether the entertainment includes balls being juggled, objects shot from a gun, sand traveling through an hour glass, or water emitted into the air or raining down, the level of entertainment typically relies on how precisely the moving objects or forms may be controlled.

[0005] In addition, due to the laws of physics and gravity, the motion of such traveling objects or forms may be predictable or assumed by the human brain. In fact, when humans view such moving objects, the human brain may quickly sense that the object may be moving under the combined forces of its launch force and/or gravity. For example, the human brain will watch balls being juggled and will sense that the balls are undergoing forces from the juggler as well as forces due to gravity. If however, the moving object exhibits an unexpected movement (for example, hanging in mid-air for a moment due to reduced gravity), the human brain will immediately

recognize the movement as unnatural and will alert the frontal cortex of the viewer to pay attention. Accordingly, if such an event were possible, it may be used as an exciting form of entertainment.

[0006] Another example involves how the human brain perceives different forms of falling water, either in free fall or running down a vertical or slanted surface; or how the human brain perceives defines shapes or sprays of water, in any direction, where the water droplets defined some type of shape, such as a stream, fan or cone of water emitted from a nozzle. In this example, when humans see water, either as spraying in a form as described above, or falling as rain, or running down a surface, with its inevitable waves and surface indications, human minds quickly sense that the water is moving under the combined forces of its emitting force (pressure ejecting it from a nozzle) and gravity (in the downward direction). Human brains are so used to seeing water in these conditions that we immediately sense it as expected movement. If, however, you see water fall, or even stay motionless, in a reduced gravity or zero gravity environment, our brains sense this. Even a slightly reduced gravity field produces movement that our brains tell us is not being influenced by “normal earth gravity.”

[0007] Accordingly, there is a need for a system and method to provide such visual effects in a display, form of entertainment or visual effect.

[0008] There is also a need for a system and method that may alter the visual appearance of moving objects, materials and forms.

Summary of the Invention

[0009] The present invention is described in the Detailed Description of the Preferred Embodiments, as well as in the claims, appearing later. The following Summary of the Invention describes aspects of the present invention.

[0010] An aspect of the invention regards providing a visual effect of moving objects or forms seemingly defying the force of gravity. To this end, the system embodying the invention may include a material delivery device that may deliver solid or liquid objects, e.g., water. A projector system may take video of the moving objects or form and project it thereon, and a controller may control the foregoing. Because of the manner in which the human brain perceives motion, depending on the lighting of the surrounding environment, and depending on the relative speed of the moving

objects or form, and the speed of the projected objects or forms, the moving objects or forms may appear to be suspended in midair, moving more slowly than the observer would expect due to the force of gravity, or even moving upward.

[0011] Another aspect of the invention regards a display which incorporates features described above. The display may include several sections or structures having a surface down which water may flow. [COMPLETE]

[0012] Other aspects of the present invention are described herein.

Brief Description of the Drawings

[0013] Various other objects, features and attendant advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein:

[0014] **FIG. 1** shows aspects of an optically enhanced display according to exemplary embodiments hereof;

[0015] **FIGS. 2-4** show aspects of water delivery devices according to exemplary embodiments hereof; and

[0016] **FIGS. 5-9** show aspects of an optically enhanced display according to exemplary embodiments hereof.

[0017] **FIG. 9** shows part of a display embodying aspects of the current invention, during the daytime.

[0018] **FIG. 10** shows a display embodying aspects of the current invention, during the nighttime.

[0019] **FIG. 11** is an isometric view of a display structure and other display components.

[0020] **FIG. 12** is a plan view of a display structure and other display components.

[0021] **FIG. 13** is a plan view of a display structure showing projector locations and associated projections.

[0022] **FIGS. 13A-G** show projector and projection configurations.

- [0023] FIG. 13AA shows infrared components along with a projector.
- [0024] FIG. 14 is a side section view of a display.
- [0025] FIG. 14A is enlarged side section view of a part of a display.
- [0026] FIG. 15 is a side section view of a projector and other display components.
- [0027] FIG. 16 shows part of a display structure with different intensity lighting.
- [0028] FIGS. 17A-17AAAA comprise a series of sequential views of a display feature provided by an embodiment of the current invention during the daytime.
- [0029] FIGS. 18A-18XXX comprise a series of sequential views of a display feature provided by an embodiment of the current invention during the nighttime.
- [0030] FIG. 19 shows a series of frames regarding the recording, processing and projecting of images, as well as a reversal effect timeline.
- [0031] FIG. 20 shows a flowchart regarding the manner in which recording and projection may occur in relation to an overall display.

Detailed Description of the Preferred Embodiments

[0032] A system and method according to preferred embodiments of the current invention are described with reference to the figures.

[0033] Preferred embodiments hereof provide a system **10** that may include a presentation, show, display, performance, production, exhibition, demonstration, arrangement, or any type of visual effect that may involve projecting light, images, video, animation, graphics, phantasmagorias or other types of projected elements onto one or more physical objects or forms. The physical objects or forms may include any types of materials including, without limitation, solid forms, liquid forms, gaseous forms, and any combination thereof. At least a portion of the projected elements may be reflected off the physical objects or forms and be visible to viewers. In this way, the projected elements may alter, change or otherwise affect the visual appearance of the physical objects or forms.

[0034] In some preferred embodiments the physical objects or forms may include movement. That is, at least a portion of the physical objects or forms may be moving in one or more directions. For example, if the physical forms include solid

materials such as a mass of sand or pebbles, at least a portion of the sand or pebbles may be falling through the air and/or running down a ramp. In another example, if the physical forms include liquid materials such as water, at least a portion of the water may be falling through the air as water droplets and/or flowing down the side of a structure (e.g., down a wall). In another example, if the physical forms include gaseous materials (preferably visible gases), at least a portion of the gas may be flowing or otherwise moving in one or more directions. The physical objects and/or forms may include any combinations of solids, liquids or gases, and that any portion of any combination of these materials may be moving in any direction.

[0035] For the purposes of this specification and to demonstrate the structure and functionalities of the current invention, the system **10** may be described with relation to the moving physical forms as including liquid material such as water. However, one of ordinary skill in the art, upon reading this specification, will recognize that the system **10** may be used with any type or combinations of types of physical objects and/or forms (liquids, solids and/or gasses), and that the scope of the system **10** is not limited in any way by the type or combinations of types of physical objects and/or forms that it may utilize.

[0036] In addition, while this specification may refer to the projected elements primarily as video, the projected elements may include any other types of projectable media such as animation, computer generated images, moving sequences of images, light, other types of media or any combination thereof.

[0037] In some embodiments wherein the physical forms may include moving water, the video footage projected onto the moving water may include video footage taken prior of the same or similar moving water. For example, video footage may be taken of a curtain of falling water droplets and the video may then be projected back onto the same curtain of falling droplets. In this case, the resulting appearance of the water may be that of a greater volume of falling droplets since the actual droplets, as illuminated by ambient light, may also be amplified by the brightly projected images of the projected droplets, falling at the same velocity and acceleration.

[0038] It is not necessary that each projected falling drop visually map itself onto a corresponding drop, as the general mass of falling droplets may provide the rough equivalent of a screen with integral movement, onto which the projected droplets

appear. In a preferred embodiment, the observer is preferably not aware of any projection, provided care is taken not to reveal the projector, or the beam from the projector (such as if the room were smoky and the beam could be seen in the smoky air), or the projector is aimed in such a way that the lens of the projector can be seen (which can easily be avoided). It should be noted that since a light ray, such as from a projector, strikes a non-opaque object, such as a translucent or transparent rain drop, the light is not all reflected back toward the source; most of the light is refracted by the difference in indices of refraction between air and water, and thus continues generally forward, but at a bent angle. Thus, in a preferred embodiment, the rain or falling droplets, are best seen when back lighted.

[0039] In a preferred embodiment, aspects of the projected video may be altered prior to being projected back onto the water. For example, the playback speed of the video footage may be slowed down, sped up or otherwise varied or altered. In another example, the physical orientation of the projected video footage may be set so that the projected video footage of the moving water may not be exactly aligned with the moving water upon which it may be projected. For example, the delivered water may include a curtain of water droplets falling directly downward, while the falling water droplets depicted in the video footage may be set to fall downward at an offset angle. In this way the projected video footage may affect the visual appearance of the falling water.

[0040] Continuing with the above example, when the playback speed of the video footage of the falling water droplets is slowed down and projected back onto the curtain of falling droplets, a viewer of the water may see a combination of the actual water droplets falling at a normal speed or acceleration and the projected images of the water droplets falling at a slightly slower speed or acceleration. The brain of the viewer may subconsciously combine the two speeds (e.g., may average the two speeds) of the real and projected rates of speed, such that the perceived overall speed of the falling water droplets may suddenly appear to be slowing down in mid-air. A similar phenomenon may result when the speed of the projected video is increased, with the viewer perceiving the water as speeding up.

[0041] In a preferred embodiment, the foregoing may occur in an environment where the ambient light is considerably brighter than the projected brightness. In this embodiment, then the average of the real and projected speeds is not half and half,

but is biased in favor of the projected speed. In a reasonably dark environment, the amount of bias towards the projected speed increases.

[0042] In addition, if the video footage is slowed to a rate that approaches zero (e.g., motionless) then the water droplets may appear to be hanging in mid-air, in complete defiance of gravity. Furthermore, if the video footage may be reversed such that the projected water droplets may be traveling upward, the perceived motion of the droplets may be that of rain falling upwards. Given this example, it can be seen that varying the upward and downward rate of the projected water droplets, in an interesting and artistic manner, may result in the very real appearance that the droplets (e.g., rain), is falling faster than gravity should allow, slower than gravity should allow, stopped, or in reverse of, and any interesting combination of these in sequence. In addition, such sequencing can be coordinated with music to create a very artistic composition.

[0043] It is not necessary that the projected imagery be the actual filmed images of rain or other moving object or form. Computer graphics may be used and may allow the creation of virtual images of rain drops or other moving objects or forms, which can be used as described above, or even changed in size or colored, or turned from rain into sparkles or other pointillist objects in a field.

[0044] Non vertical movements may also be introduced, giving the illusion that the moving objects or forms are falling or moving along field lines affected by some non-seen force. For example, if the orientation of the projected video footage is set to an offset angle compared to the actual falling water droplets, a viewer may see a combination of the actual water droplets falling at an expected angle (e.g., directly downward) and the projected images of water droplets falling at the offset angle. The brain of the viewer may subconsciously combine the two trajectories (e.g., may average the two trajectories) such that the perceived overall trajectory of the falling water droplets may appear to be suddenly pushed at an offset angle giving the illusion that the droplets are falling along field lines or trajectories affected by some non-seen force.

[0045] The above examples are meant for demonstration purposes and other embodiments are within the scope of the current invention. For example, the video footage may be altered in any way prior to being projected onto the moving object or

form, e.g., onto flowing water, such that the resulting perceived appearance of the water or other object or formation may include any type of altered appearance. It is also understood that while these examples included video footage projected onto falling water droplets, any type of video footage may be projected onto any formation of liquid.

[0046] Further aspects of the system **10** and its various elements will next be described in more detail. Additional aspects of the system **10** will also be provided through the descriptions of various examples of use.

[0047] In a preferred embodiment as shown in **FIG. 1**, the system **10** may include a water delivery system **100**, a projector system **200**, a controller **300**, and other elements or components as required by the system **10**. As shown, the water delivery system **100** may deliver water **102** (depicted as dashed lines to represent any type, shape or formation of water), and the projector system **200** may project video footage **202** onto at least a portion of the water **102**.

Delivery System

[0048] In a preferred embodiment, the system **10** may include a delivery system **100** that may deliver materials, object and/or physical forms such as water **102**, or other types of materials such as solids and/or gases, within the system **10**. Modified video footage **202** may then be projected onto at least a portion of the delivered water or other object or form **102** to visually alter the appearance of the water or other object or form.

[0049] In some exemplary embodiments hereof, the delivery system **100** may include material delivery devices **104-1**, **104-2**, ... **104-n** (collectively and individually **104**). In the example where the materials may include water, the material delivery devices **104** may include, without limitation, water nozzles, water manifolds, water misters, water jets, SHOOTER® delivery devices, waterfalls, other types of material delivery devices **104** and any combination thereof. In this way, the delivered water **102** may be moving, flowing, running, falling, spraying, shooting, sprinkling or otherwise may include any type of movement. While **FIG. 1** depicts three materials delivery devices **104**, it is understood that any number of any combinations of types of materials delivery devices **104** may be used by the system **10**.

[0050] In addition, the water **102** may be delivered in any form or shape, or in any combinations of forms and shapes including, without limitation, droplets, sheets,

curtains, mists, sprays, streams (laminar or otherwise), blooms, fans, cones, funnels, waterfalls, waves, other forms or shapes and any combination thereof. It is preferred that the delivered water **102** include at least a portion of water **102** that may include movement, and the movement may be in any direction or combinations of directions. In a preferred embodiment hereof as shown in **FIG. 2**, the delivered water **102** may free fall through the air. For example, in one implementation the water delivery devices **104** may include manifolds **104** that may release water droplets that may free fall directly downward through the air (as depicted by arrow **A**). In another embodiment as shown in **FIG. 3**, the water **102** may be emitted in an upward direction (e.g., at an angle between 0° and 90°) so that the water **102** may first include an upward/forward trajectory depicted by arrow **B** followed by a downward/forward trajectory depicted by arrow **C** (e.g., a parabolic trajectory). In another example, the water **102** may be emitted from a fan such that the water **102** can be made to appear to accelerate out of the fan at varying speeds. In yet another exemplary embodiment, the water **102** may be emitted downward by a nozzle at a speed that may be faster than the speed of free falling water.

[0051] In another exemplary embodiment hereof as shown in **FIG. 4**, all or a portion of the delivered water **102** may run down a surface **106** of a structure **108** that may include any shape or form. The surface **106** may be vertical, slanted or any combination thereof. For example, the water **102** may be released by the materials delivery devices **104** onto a slightly non-vertical wall **108** such that the water **102** may then run down the surface **106** of the wall **108** (depicted by arrow **D** in **FIG. 4**). In another example, the wall **108** may be vertical. In another example, the structure **108** may include surfaces **106** that may be vertical and surfaces **106** that may be non-vertical (e.g., slanted), and any combination thereof. In another example, the structure **108** may include channels or other geometries that may generally guide the water **102** as it may flow down the structure **108**. It is understood that the structure **108** may include any types of forms with any types of surfaces upon which water **102** may flow.

[0052] In addition, in one exemplary embodiment, the water **102** may be released continuously so that the water flow may be even and continuous (e.g., continuous free falling rain droplets of water). In another exemplary embodiment, the water **102** may be released in non-continuous patterns. For example, for water **102** released to flow down a structure **108** (sloped or otherwise) in varying spaced surges,

the crest of each surge may appear as a white froth wave front running down the surface at the speed expected given the influence of gravity. In this case, if imagery of white, frothy waves **202** is superimposed on the real waves **102**, the apparent velocity altering fall rate of visual combination can also be achieved.

[0053] It is understood by a person of ordinary skill in the art that the examples described above are meant for demonstration purposes and that the water **102** (or other types of materials) may be delivered by the material delivery devices **104** in any form(s) at any time, continuously or non-continuously or in any combination thereof. For example, a number of solid particles may be emitted from delivery devices **104** that may behave as a liquid. Alternatively, a number of larger solid objects may be delivered.

[0054] As showing further alternatives within the scope of the current invention, any particular material delivery device **104** may deliver water **102** in one form while another material delivery device **104** may deliver water **102** in the same or different form. In this way, a multitude of material delivery devices **104** may deliver water **102** (or other types of materials) in a variety of forms, and each form **102** may be synchronized, orchestrated and/or choreographed with each other form of delivered water **102** as desired. It is also understood that the scope of the system **10** is not limited in any way by the form(s) that the delivered water **102** may take.

[0055] In addition, light (e.g., video footage **202** emitted by the projector system **200**) may intersect particles of water (e.g., water droplets **102**), a portion of the light **202** may be reflected by the water **102** while another portion of the light **202** may pass through the water (and be refracted due to the differences of indices of refraction between water and air). Accordingly, it is preferred that regardless of how the water **102** may be delivered, and regardless of its shape or form, the water **102** may include water particles (e.g., droplets), or combined water particles (e.g., combined to form streams, fans, funnels, blooms or other forms) that may include adequate surface areas (individually or in aggregate across all of the water **102**) for an image to be projected onto and be discernible by a viewer of the water **102**. That is, it is preferable that the general mass of flowing water **102** provides a rough equivalent of a screen with integral movement, onto which the projected video **202** may appear. In this way the viewer may see the falling or flowing water **102** as well as the projected video footage **202** that may be reflected by the falling or flowing water **102**. It is understood

that if the delivered materials include other types of forms such as solids (e.g., sand or pebbles) or gasses, that the solids or gasses may also provide an adequate screen onto which the video may be projected onto.

[0056] Also, as shown in **FIG. 5** and according to exemplary embodiments hereof, the material delivery system **100** may include a backdrop **110** that may include a reflective surface **112**. The reflective surface **112** of the backdrop **110** may be positioned on the opposite side of the delivered water **102** from the projector system **200** such that the portions of the projected video footage **202'** that may pass through the water **102** may be reflected off of the reflective surface **112** of the backdrop **110** and back through the water **102** to the viewer. In this way, the reflected video footage **202'** off the backdrop **110** may combine with the projected video footage **202** (reflected off the water **102**) to form an image of higher intensity. The reflective surface **112** may be planar or may include curvatures (e.g., may be concave) or lenses so that it may compensate for the refraction of the light through the particles of water **102**.

[0057] In another exemplary embodiment hereof, the system **10** may utilize naturally delivered water **102** in the form of falling rain, a naturally occurring waterfall, a naturally occurring stream of water, or other types of naturally occurring water forms. It is understood that the system **10** may also utilize a combination of naturally occurring delivered water **102** as well as water **102** delivered by the materials delivery system **100**. The projector system **200** may also be used with solid objects and other moving forms besides water.

Projector System

[0058] In a preferred embodiment hereof, the system **10** may include a projector system **200** that may project video footage **202** onto the delivered water **102** as shown in **FIG. 1**, or onto other materials, objects or forms.

[0059] For example, the projector system **200** may include one or more multimedia projectors **204-1**, **204-2**, ... **204-n** (collectively and individually **204**) as shown in **FIG. 6**. The multimedia projectors **204** may include any type of multimedia projectors **204** including but not limited to video projectors **204**. The projectors **204** may be digital devices, analog devices or any combination thereof.

[0060] The projector system **200** and/or the projectors **204** may receive multimedia signals (e.g., video signals) from the controller **300** and may convert the

signals to video and project the video **202** onto the delivered materials such as the delivered water **102**, solid materials or other objects or forms. As will be described in other sections, the video footage may be captured in a variety of ways. The video footage **202** may be modified, manipulated or otherwise altered by the controller **300** prior to sending the video **202** to the projectors **204**. For example, as described above, the controller may be programmed to slow down or speed up the video footage **202** so that its projection onto the water **102** may cause the water **102** to appear to slow down or speed up in mid-air. This will be described in further detail in other sections.

[0061] The signals may include, without limitation, video signals, animation signals, lighting signals and other types of signals. The projection system **200** and/or the projectors **204** may receive the signals from the controller **300** via wireless communication technologies such as WiFi, Bluetooth, cellular technology, RF and other wireless technologies, through transmission lines, wires or cables, or by any combination thereof.

[0062] As shown, some projectors **204** may project video footage **202** onto the same delivered water **102** (e.g., projectors **204-1**, **204-2** and **204-3** may project video footage **202-1**, **202-2**, **202-3** onto water **102-1**), some projectors **204** may project video footage **202** onto different delivered water **102** simultaneously (e.g., projector **204-3** may project video **202-3** onto water **102-1** and **102-2** at the same or different times), or any combination thereof. Each projector **204** may be orchestrated, choreographed and/or synchronized with each other projector(s) **204**, and with each water delivery device **104**. In this way, the material delivery devices **104** may release the water **102** in a choreographed fashion with respect to each other materials delivery device(s) **104**, and the projectors **204** may project video footage **202** onto the water **102** in a synchronized and orchestrated fashion with respect to the released water **102**.

[0063] In a preferred embodiment, the projectors **204** may project video footage **202** of high resolution so that the video **202** may be clearly discernable. As an alternative, the projectors may project video footage **202** to solid and other materials or forms besides water. High definition is not necessary as well.

[0064] In addition, it is preferred that the projectors **204**, as well as the beams of light that the projectors **204** may emit, may be hidden from view so that the viewers of the water **102** may not notice the projectors **204**, and may not perceive that the

water **102** is reflecting projected video footage **202**. The projectors **204** may be hidden using one-way mirrors or shades, by disguising the projectors **204**, through the use of reflectors to bounce the video **202** through different paths to the water **102**, and in other ways. In this way, as the water **102** may be visually altered by the projected video **202** (e.g., is caused to visually slow down, speed up, change directions, etc.), without the viewer discerning how this is being accomplished. Accordingly, the system **10** may provide enhanced and artistic effects for a very entertaining experience to the viewers.

[0065] The video footage **202** may be captured or otherwise obtained in a variety of ways. For example, in one exemplary embodiment hereof as shown in **FIG. 7**, the projector system **200** may include one or more video capturing devices **206** (e.g., video cameras) that may be configured to capture video footage **208** of the delivered water **102** and supply the video footage **208** (in the form of a video signal) to the controller **300**. The controller **300** may then alter the footage **208** as desired and provide the altered video footage **208a** (in the form of a video signal) to the projector **204** to be projected onto the water **102** as the video **202**. The video capturing device **206** may communicate with the controller **300** via wireless communication technologies such as WiFi, Bluetooth, cellular technology, RF and other wireless technologies, through transmission lines, wires or cables, or by any combination thereof. In addition, the video capturing device **206** may be an analog device, a digital device or any combination thereof.

[0066] Note that the video capturing methodology described above may facilitate visually manipulating delivered water **102** that may be delivered in a continual steady state, such as continuously falling rain droplets **102**, a continuous falling curtain of water **102**, continuous water **102** flowing down a structure, or in other ways that may be continuous and generally in a steady state. In this case, it may not be necessary to map the projected video footage **202** of the water particles onto the actual particles **102**, as both the projected **202** and the real fields of particles **102** may be generally uniformly distributed.

[0067] In addition, a length of video **208** may be captured and stored for later use, and the time lapse between the capturing of the video footage **208**, the altering the video footage by the controller **300**, and the projecting of the same video footage **208** onto the water **102** at a later time may not adversely affect the desired visual

outcome because the water **102** may remain in the continual steady state during the time lapse. That is, the water **102** may be generally in the same form at the time of the capturing of the video footage **208**, and again later at the time of the video projection **202**.

[0068] However, where the delivered water **102** reflects a changing or non-steady state form of water **102** (e.g., if the water **102** may be released in sporadic surges or may include frothy wave fronts running down a surface), the flow **102** may be unsteady and there may be varied spaces between the waves **102**. This may require either very precisely timed wave **102** releases, actually filmed, and then synchronized to the water waves, or else real time creation and/or manipulation of the to-be-projected wave fronts **202**. In this case, because the precise release of physical waves **102** in identical water flows and amounts may be difficult to achieve, a methodology of creating and/or manipulating the to-be-projected video footage **202** in real time just prior to the moment of its projection onto the water **102** may be used.

[0069] In one embodiment of this type, the video footage **208** may be captured and immediately altered and projected back onto the water **102** in real time. However, it can be seen that the video capturing device **206** may capture footage not only of the flowing water **102**, but also of any video **202** that may be projected onto the flowing water **102** at the same time. That is, the projector(s) **204** may be projecting video **202** onto the flowing water **102** at the same time that the video camera(s) **206** may be capturing new footage **208**. The new footage **208** may therefore include both the real delivered water **102** plus the projected video **202**, and this new footage **108** may then be projected back onto the water **102**. This may create an open positive feed-back loop of ever increasingly brighter light that may ultimately wash out the recorded footage **108**.

[0070] In this case, it may be preferred to record the footage **108** of the flowing water **102** in non-visible light (e.g., infrared) using a non-visible light recording device **206**. In this way, the non-visible light recording device **206** may only capture images/video of the delivered water **102** in infrared light, and not the images/video of the projected video **202**. The non-visible light footage may then be converted to visible imagery (e.g., by the controller **300**), modified as desired (e.g., slowed down, sped up, change the trajectory, etc.) and projected back onto the water **102** in real time or near real time.

[0071] It is not necessarily required to capture actual video footage **208** of the flowing water **102**, and computer generated images, video or animations may be used as the projected video **202** instead. For example, computer graphical software may allow for the creation of virtual images of falling rain, which can then be projected onto the water **102** by the projectors **204**. In addition, the virtual rain drops may be enlarged or reshaped to provide an enhanced effect, may be colored, or may include added graphical effects. In one example, the virtual rain may gradually or abruptly turn into sparks, flames, fireworks, or other pointillist objects, all at varying speeds and trajectories. In one example, imagery of fire could be created in a fan shaped array and projected onto the water spray **102**, again at varying speeds. And if the fan is rotated or twisted and the computer generated imagery is created to follow the outline of the resultant morphed fan shape of water **102**, the same effects as described above can be achieved. The computer generated videos may be designed to follow the curvature or motion of the flowing water **102**, the structure **108** upon which the water **102** may flow, or even the movement of the water delivery devices **104**.

[0072] In addition, the environment in which the system **10** resides may include different types of lighting which may influence the functionality of the system **10**. For instance, if the system **10** is placed in an environment where the ambient light is considerably brighter than the projected brightness, the perceived motion of the water **102** may be biased towards the actual speed of the falling water **102**. However, if the system **10** is placed in an environment with lower ambient lighting, the lower ambient lighting allows the projected video **202** to have a greater influence on the perceived motion of the visually altered water **102**, thereby biasing the visual effect towards the projected video and motion associated therewith.

Controller

[0073] In a preferred embodiment hereof, the system **10** may include a controller **300** configured to send data to and/or receive data from the material delivery system **100**, e.g., water delivery system **100**, and the projector system **200**. The controller **300** may include one or more microprocessors, microcontrollers, encoders, local or remote computers, smartphones, tablet computers, laptops, personal computers, hubs, servers or any other types of controller or any combination thereof. The controller **300** may include software, firmware, applications, programs, scripts or other types of code that may allow the controller **300** to run and perform its

functionalities. The controller **300** may include drivers to control the different systems **100**, **200**, and may be networked, paired or otherwise configured with one or more of the systems **100**, **200** as required. The controller **300** may communicate with one or more of the systems **100**, **200** via wireless technologies, Wi-Fi, Bluetooth, RF, microwave, optical, cellular or other types of wireless technologies. Alternatively the controller **300** and the systems **100**, **200** may communicate via transmission lines, wires, cables, or via any combination thereof.

[0074] The controller **300** may provide one or more of the following functionalities:

1. Interface with the materials delivery system **100** to control, operate, coordinate, orchestrate, synchronize, choreograph and otherwise manage the delivery of the water **102** or other material or object. This may include controlling one or more materials delivery devices **104** simultaneously and in parallel.
2. Interface with the projector system **200** to control, operate, coordinate, orchestrate, synchronize, choreograph and otherwise manage the capturing of video footage of the water **102**, the modification and/or alteration of the video footage of the water **102**, and the subsequent projection of the video footage **202** onto the water **102**. This may include controlling of one or more projectors **204** and/or one or more video capturing devices **206** simultaneously and in parallel.
3. Provide an interface for the user of the system **10** to program, set, or otherwise control the functionalities described in (1) and (2) above.
4. Coordinate the functionalities of the system **10** with music, lighting and other visual elements to create an expanded multimedia presentation.
5. Interface with other displays (e.g., other water displays), installations, programs or systems to correlate the functionalities of the system **10** with said other systems.
6. Control the aforementioned systems **100**, **200** depending on the type of material or object used, e.g., water, solid, etc.

[0075] The functionalities of the controller **300** described above are meant for demonstration purposes. The controller **300** may include the same, similar or other

types of functionalities described above or otherwise. It should also be noted that the system **10** is not limited in any way by the functionalities of the controller **300**.

In Use

[0076] Aspects of the system **10** will next be described by way of several embodiments of the current invention in use. The examples provided below are chosen to illustrate different types or combinations of visual experiences that the system **10** may provide to viewers. Each example may purposely demonstrate particular operational functionalities of the system **10**. The examples presented do not limit the scope of the system **10** to the specific functionalities described herein, and the system **10** may include other functionalities or combinations of functionalities that may not specifically be demonstrated in the examples but that are within the scope of the invention.

[0077] In a first example as depicted in **FIG. 8**, three projectors **204-1**, **204-2**, **204-3** may each project different video images **202-1**, **202-2**, **202-3** respectively onto three different portions of a curtain of falling water droplets **102**. In this example, because the delivered water **102** may be a continuous steady-state of falling droplets **102**, a length of video footage **208** of the water **102** may be captured prior to the visual effect being provided to observers by using a video camera **206** and stored in the controller's memory. The video footage **208** may then be altered and/or modified as desired and stored as one or more altered sequences. While **FIG. 8** shows one video camera **206** capturing video footage **208**, any number of video cameras **206** may be used to capture different sequences of video **208** from the same or from different perspectives and/or orientations with respect to the water **102** and the projectors **204** as necessary. For example, each projector **204** may have a dedicated video camera **206** associated with it to capture video footage **208** specifically for that projector **204**.

[0078] In this example, a first sequence of video footage **208** may be altered by the controller **300** to depict the rain droplets as falling at a rate of half the speed of the normally falling rain **102**. This altered footage may be stored to be projected as video **202-1**. A second sequence of video footage **208** may be altered by the controller **300** to depict the rain droplets as falling at a rate of twice the speed of the normally falling rain **102**. This altered footage may be stored to be projected as video **202-2**. And a third sequence of video footage **208-3** may be altered by the controller **300** to depict

the rain droplets as falling at the normal speed of the falling rain **102** but at an offset angle of 45° with respect to the downward trajectory of the normally falling rain **102**. This altered footage may be stored to be projected as video **202-3**.

[0079] During use, but not while the visual image of the water **102** is being altered, an unaltered sequence of the video **202** may be projected onto the water **102**. In this way, the viewers of the water **102** may see the visually unaltered water **102** with a lighting intensity that includes the intensity due to the ambient light of the environment as well as the added intensity due to the projected video **202**. Then, when the altered sequences of video **202** are applied to the water **102** instead of the unaltered sequences, the light intensity of the water **102** may not change. However, it is understood that this may not be necessary and that an unaltered video sequence **202** may not necessarily be projected onto the water **102** if not desired. In this case, the falling water **102** may first be displayed to the viewers with no projected videos **202**.

[0080] In this first example, the viewers may first see the falling water **102** as a standard water display (with no visual alterations). Then, in a sequential implementation, the projectors **204** may project altered video footage **202** onto the water **102**. For example, the first projector **204-1** may first project the altered video **202-1** onto the upper portion of the falling water droplets **102**. This may alter the visual appearance of the upper section of water **102** to be seen as water droplets **102** slowing down in mid-air. Shortly thereafter, the second projector **204-2** may project the altered video footage **202-2** onto the middle portion of the falling water droplets **102**. This may alter the visual appearance of the middle section of the water **102** to be seen as water droplets **102** speeding up in mid-air. Then, the third projector **204-3** may project the altered video footage **202-3** onto the bottom section of the falling water droplets **102**, and this may alter the appearance of the bottom portion of water **102** to be seen as water droplets **102** being driven to the side at a slanted trajectory.

[0081] The system **10** may apply the above affects to the falling water **102** in succession and then return to normal (with projections of unaltered video **202** or no projections **202**). In this way, the short visual change in appearance of the falling water **102** (the slowing down, the speeding up and the slanted trajectory) may catch the attention of the viewers and then return to normal, causing confusion, curiosity and wonderment regarding what they may have just witnessed.

[0082] Continuing on with the same example, the system **10** may then begin projecting the altered video footage **202** onto the falling water **102** but in different sequences and to different portions of the water **102**. For example, the first projector **204-1** may project the altered video **202-3** of the sideways trajectory, the second projector **204-2** may project the altered video **202-1** of the slowed down water, and the third projector **204-3** may project the altered video **202-2** of the sped up water. In this way, the visually altered falling water **102** may again catch the attention of the viewer(s) but this time the sequences may be different causing further confusion, curiosity and awe.

[0083] In a second example as shown in **FIG. 9**, a first video capturing device **206-1** may be configured with a first projector **204-1** and a first water flow **102-1**, and a second video capturing device **206-2** may be configured with a second projector **204-2** and a second water flow **102-2**. In this way, the first video capturing device **206-1** may capture a sequence of video **208-1** of water **102-1**, and the video sequence **208-1** may be altered and projected back onto the water **102-1** as video **202-1** by the projector **204-1** to visually alter the water's **102-1** appearance. At the same time, the second video capturing device **206-2** may capture a sequence of video **208-2** of water **102-2**, and the video sequence **208-2** may be altered and projected back onto the water **102-2** as video **202-2** by the projector **204-2** to visually alter the water's **102-2** appearance.

[0084] In this example, the delivered water flows **102-1 102-2** may include any type of forms (e.g., curtains of water droplets, water streams, fans, funnels, blooms, waterfalls, etc.), and it may be preferable that the water forms **102-1, 102-2** be positioned in close proximity to one another (e.g., side-by-side). In this way, the video footage **208-1, 208-2** may each be altered in a way that may result in depicting the water flows **102-1, 102-2** as interacting within one another (e.g., bumping one another, dancing with one another, etc.).

[0085] For example, video footage **208-1** may be modified such that the projection of video **202-1** may affect the visual downward trajectory of the water **102-1** as suddenly shooting sideways in the direction of the water **102-2** and then returning to its normal trajectory. This may appear as a "hip bump" from water **102-1** to water **102-2**. The water **102-2** may then be depicted as reacting to the "hip bump" from water **102-1**. For instance, the first reaction from water **102-2** may be to slow down its

downward flow due to the bump. To create this effect, the video footage **208-2** may be modified to slow down such that the projection of the video **202-2** onto the water **102-2** may visually affect the water **102-2** in the same way (e.g., it may appear to stall in mid-air for a moment). Then, the water **102-2** may be shown to react to the hip bump from the water **102-1** by giving the water **102-1** an even larger hip bump. In this case, the video footage **208-2** may be altered to depict an even larger sideways trajectory towards the water **102-1** and then returned to its normal trajectory. It can be seen that this playful interaction may continue between water **102-1** and water **102-2** in a variety of different sequences.

[0086] Continuing with this second example, the visual appearances of the water **102-1** and **102-2** may also be altered simultaneously and in real time such that the water flows **102-1**, **102-2** may appear to be dancing with one another. In this case, the video capturing devices **206-1**, **206-2** may each capture videos **208-1**, **208-2** respectively and simultaneously, the videos **208-1**, **208-2** may each be altered individually, and the projectors **204-1**, **204-2** may each project the videos **202-1**, **202-2** respectively and simultaneously onto the water flows **102-1**, **102-2**. The simultaneous projections **202-1**, **202-2** onto each water flow **102-1**, **102-2** may be chosen so that the changes in the visual appearances of the water flows **102-1**, **102-2** may be choreographed with one another in real time.

[0087] For example, the visual appearance of the water flows **102-1**, **102-2** may be affected simultaneously to show the water droplets **102-1** as slowing down while the water droplets **102-2** may speed up. The affects may then be changed such that the droplets **102-1**, **102-2** may both show as being suspended motionless in mid-air. The affects may then switch again to show the trajectories of the water droplets **102-1**, **102-2** as reversing in opposite directions, as shooting into one another, shooting apart, etc. It can be seen that any type of effects may be applied to the water flows **102-1**, **102-2** in a simultaneous choreography such that the water flows **102-1**, **102-2** may be perceived to interact with one in any way.

[0088] The system **10** may be used by itself and provide the visual effects to observers. Alternatively, the visual effects may be incorporated into or used with water and lighting displays having other visual, audio and other effects. To this end, the visual effects provided by the system **10** may complement other effects provided by

the display. The system **10** may be added to existing displays or included in the design of a display being developed.

[0089] Embodiments of a system or display **1010** involving aspects of the current inventions discussed above and below are now described with references to **FIGS. 9-18**. Display **1010** may comprise various features and structures, such as those described above alone and/or combined with other types of displays and features. The size and/or overall configuration of display **1010** may vary. For example, display **1010** may be relatively small so as to be viewed by a few observers in close proximity. Alternatively, however, display **1010** may be relatively large so as to cover a significant area, thereby allowing observers to walk in or around the display and/or view various features from a distance.

[0090] **FIGS. 9 and 10** show an embodiment of display **1010** during the daytime and nighttime. As shown, this embodiment is relatively large; allowing observers to walk amongst its features and providing an arena or stadium environment. However, the display of the current invention may be smaller and/or configured differently. Display **1010** may include features and effects, along with the structure to provide a projection mapping feature as described above, and as described further below.

[0091] Display **1010** may include several primary systems: one or more sections **1100** which deliver material (e.g., water); a projection system **1200** which may capture video footage of the water, project modified video footage (based on modifications or alterations of the captured video footage) back onto the water and/or project other images or video onto the water; and a controller **1300** which may modify the captured video footage and perform other control functions over different aspects of display **1010**.

[0092] Sections **1100** are now further described. Display **1010** may include one or more sections, features, delivery systems or portions **1100**, such as the three sections or water delivery systems **1100** shown in the figures. Section, feature or portion **1100** may generally comprise structure **1108** which may be configured to accommodate the overall display **1010**. In the embodiment of **FIGS. 9-10**, each structure **1108** may include walls **1109** and other structural components, of varying scale, height, width, shape and other dimensions or characteristics. For example, structures **1108** may be sized to resemble buildings.

[0093] Structures **1108** may include a frame or other support structures that support walls **1109** and/or other aspects of structure **1108**. As shown in FIGS. 9-10, structures **1108** of features **1100** may be spaced around or in proximity to plaza **1030**. One or more of the sections, features or portions **1100** may be separated by walkways, stairways, gaps or other openings **1101**, which may provide observers with access to view the features of display **1010** from within display **1010** or in proximity or outside thereof. For example, opening **1101** may include observation platform or deck **1130** and stairway **1132**. However, other configurations of sections or features **1100**, and openings **1100**, are within the scope of the current inventions. As discussed in more detail below,

[0094] Structure **1108** may generally include top section **1120** which may house or support other components as discussed later. Structure **1108** may also include surface **1106** which extends downward from top section **1120** in a parabolic, curved or other sloped configuration, and along or down which water or other materials **1102** may flow. Surface **1106** may comprise one or more panels joined together. Alternatively, surface **1106** may be formed when concrete is poured or when other material(s) is/are deposited to form structure **1108**. In the embodiment of FIGS. 9-10, water **1102** is delivered to and flows down surfaces **1106**, and surfaces **1106** are inward-facing towards plaza **1120**. Where display **1010** involves water, surface **1106** is preferably finished to be waterproof.

[0095] Surface **1106** may include a texture that may be molded or formed therein as structure **1108** is constructed. As an alternative, a texture may be applied to surface **1106**. A texture to surface **1106** preferably causes the water **1102** flowing down to aerate or flow with turbulence, and become more opaque as it travels down the surface **1106**. As discussed above, and as discussed in more detail below, the opacity of water **1102** may more effectively interact with projected video footages or images to facilitate providing the visual effects of display **1010**.

[0096] Section **1100** may include one or more material delivery devices or assemblies **1104** that may deliver water or other material to flow down surface **1106**. In the embodiment of FIGS. 11-13, delivery devices **1104** may be positioned along the top of wall **1109**, or along the top of structure **1108**. As an example, these delivery devices **1104** may comprise boxes, which fill with water, and from which the water **1102** is ejected up and forward (as shown in FIG. 3).

[0097] As shown in the section view of **FIG. 15**, box **1104** may include a partition **1105** that extends along the length of box **1104**, and that may effectively divide the interior of box **1104** into an inner and outer chambers **1104a**, **1104b**. A gap **1104c** may exist between the bottom of partition **1105** and the bottom of box **1104**. Compressed air may be fed into box **1104** at or near the top of outer chamber **1104b**, thereby directing the water downward, through gap **1104c** and then upward through inner chamber **1104a** and out of box **1104**. It should be noted that the compressed air that is fed into outer chamber **1104b** need not serve to aerate the water in box **1104**. Indeed, the water contained in box **1104** may generally flow in a laminar state through and out of box **1104**. The water emitted from boxes **1104** may assume a turbulent state as it flows down walls **1106**, without any the need for any device that affirmatively aerates the water. As discussed elsewhere, the turbulent state of the water flowing down walls **1106** may facilitate the reflection of infrared light off the water and recording thereof. Other types of delivery devices such as nozzles or manifolds may also be used to deliver water **1102** to surface **1106**. These other types of delivery devices also need not serve to impart turbulence to the water prior to the water flowing down walls **1106**. Other embodiments of the current invention may imply near infrared as opposed to infrared light, or other wavelengths of light. Accordingly, the reference to infrared light throughout the specification may alternatively refer to near infrared or other wavelengths of light, i.e., illuminated with radiation outside the visible spectrum.

[0098] As an example, which is not intended to limit the scope of the current invention, in the embodiment shown in **FIGS. 9-13**, display **1010** may include three sections **1100**, where fifty one (51) or some other number of boxes **1104** may be installed along the top edges or top sections **1120** of each section **1100**. Boxes **1104** may be one meter wide or some other suitable dimension. The boxes **1104** may be individually controlled to push water up and over the edge on programmed cues.

[0099] Projection system **1200** is now further described with reference to **FIGS. 11-15**. Projection system **1200** may include one or more projectors **1204** that may project video footage or other images **1202** onto water **1102**. Projection system **1200** may also include one or more video cameras or other video capturing devices **1206** that may record video footage of the water **1102** as it flows down surface **1106**. It is preferred that video projectors **1204** are relatively powerful so that they may sufficiently

project their video and/or other images to reach the other side of display **1010** as discussed below.

[00100] Projectors **1204** may be positioned or distributed along top sections **120** of structures **1108**. In the embodiment of FIGS. 11-13, top section **120** of each structure **1108** may include seven projectors **1204**, so that display **1010** includes twenty one (21) total. However, other numbers of projectors **1207** may be used, and the current inventions are not limited to the embodiment shown in FIGS. 11-13.

[00101] Each projector **1204** may be aimed and focused on a surface **1206** of another section **1100**. For example, projectors **1204** may be aimed and focused on opposite section(s) **1100**, e.g., across plaza **1030**. It is preferred that the light **1202** emitted from projector **1204** has sufficient lumens to form a discrete projection on the surface **1206** at which it is aimed.

[00102] The video footage or other image **1202** emitted from projector **1204** may comprise white light or a spectrum of colors. **FIG. 16** shows an image **1220** comprising an individual colored field projected by a single projector **1204** onto the surface **1106** of a section **1100**. As shown, image **1220** may be projected onto only part of surface **1106**. The image **1220** shown on the left of wall **1106** may represent a screen, section or an area of wall **1106** that is covered by the projection from one of the projectors **1204**. Successive projectors **1204** may project adjacent and/or overlapping screens onto adjacent and/or overlapping sections of wall **1106**. These screens may be “stitched” or otherwise overlaid or coordinated together so that the overall image **1220** that spans the width of wall **1106** comprises the desired contiguous image. The stitching together of successive screens may occur through software. The intensity, e.g., in lumens/unit of area squared, of the projected image **1232** may vary depending on the location and curvature of surface **1106** a particular portion of the projected image may appear. Generally, portions of the projected image **1232** appearing near the bottom of wall **1106** may be projected with more lumens. To this end, **FIG. 14** shows an example projection path that appears near the base of wall **1106** (where the human figure appears). Because wall **1106** at this lower section has a larger horizontal component in its curvature than for sections higher up on wall **1106**, the projected image **1220** may be diffused. To address this situation, so that the resolution or brightness of the overall image **1220** appears consistent along the height of wall **1106**, the image **1220** may be projected with more lumens per unit area squared for the

bottom portion of the image. And higher up wall **1106**, where the vertical component of the curvature is larger, the image **1220** may be projected with fewer lumens per unit area squared. This variation in brightness may be accomplished through software, e.g., through a software masking technique. For example, software may be used to process the digital representation of the image to be projected so that certain portions of the projected image are delivered brighter than other portions. This is discussed in more detail later on.

[00103] The manner in which projectors **1204** are positioned, and are directed and focused is now further described with reference to **FIGS. 11-15**. In the embodiment shown, display **1010** may include three sections **1100A**, **1100B**, **1100C** that may be separated by openings **1101**. Each section **1100** may include a number of projectors **1204** aimed at the surface(s) **1206** of opposite section(s) **1100**.

[00104] In the embodiment with twenty-one (21) projectors **1204**, seven projectors **1204** may be aimed at a particular surface **1206**, so that their collective projections cover the entire surface **1206**, or desired portion thereof, i.e., the seven projectors **1204** may project an image or otherwise illuminate the entire surface **1206**, or desired portion thereof. These projectors **1204** may be located on different sections **1100**, while all aiming at desired portions of a particular surface **1206**. As noted earlier, the screens provided by each of the projectors may be stitched together to form one contiguous image across the width of wall **1106**.

[00105] FIG. 13 shows an example where projectors 1204A, 1204B, 1204C are located on section 1100A, and projectors 1204D, 1204E, 1204F, 1204G are located on section 1100B. In this embodiment, all projectors 1204A-G are aimed at different portions of surface 1106C of section 1100C, but the collective areas of their projections or expanding beams 1202 may cover the entire surface 1106C. Some portions of projections 1202 may be blended with portions of other projections 1202, while other portions of projections 1202 may not be blended. In general, adjacent projectors 1204 may project adjacent screens on the desired surface 1106. The manner in which the projections 1202 are combined and/or collectively project images onto surface 1106 is discussed in more detail later.

[00106] FIGS. 13A-13G provide more detail about how projectors 1204A-G are positioned on top portions 1120A, 1120B of sections 1100A, 1100B. As shown, each

camera 1204 may be mounted and aimed so that the centerline of their projections 1202 may deviate from the display or facility axis 1020 by a desired angle. The angle of deviation may generally depend on where the projector 1204 is located in relation to surface 1106 it is aimed at. In any event, the projections 1202 from projectors 1204A-G collectively cover surface 1106C. The angles of deviation identified in FIGS. 13A-13G are examples only, and projectors 1204 may be mounted at other angles of deviation.

[00107] For clarity, FIG. 13 shows only the projections 1202 emitted by the seven projectors 1204A-G. In operation of the twenty-one (21) projector embodiment, however, the other fourteen (14) projectors would also emit projections 1202 onto surfaces 1106A, 1106B. The timing and content of the projections 1202 are discussed in more detail later, but it should be noted that an aspect of the current inventions relates to sequential or simultaneous projections 1202 being emitted from projectors 1204, and other types of visual effects.

[00108] The content transmitted to the projectors 1204 (that is then projected to wall 1106) may be divided into separate screens, with each screen covering a portion of wall 1106. In a preferred embodiment, seven projectors may be used to project portions of the overall image to the opposite wall 1106. As noted above, these seven projections may be stitched together to form the desired contiguous projected image across the width of wall 1106. Other numbers of projectors 1204 and screens may be used within the scope of the current inventions.

[00109] The operation of projectors 1204 is now further described. In general, projectors 1204 may receive video or other signals from a central server or controller 300 as shown in FIGS. 1 and 6-9, and based on these signals, projectors 1204 may project the desired content. Controller 300 may control the content to be projected as well as the timing of when such projections will be emitted. As such, controller 300 determines and coordinates the projected content 1202 so that the images or visual effect(s) 1220 appearing on one or more of surfaces 1106A, 1106B, 1106C are coordinated. To this end, it should be noted that the images or visual effects on surfaces 1106A, 1106B, 1106C need not be the same, but may vary so as to provide an overall coordinated display.

[00110] The recording of video footage 1208 and the manner in which it is processed and provided to projector 1204, so that projected video footage 1202 may be projected onto surface 1106 is now further described, with reference to a single projector 1204 as an example. In this example, infrared technology may be used, though other embodiments need not use infrared. As described above, the projector 1204 may project or send projected video footage 1202 onto a specific area of an opposite wall 1106.

[00111] This preferred embodiment may include an infrared system 1230 associated with a projector 1204. More specifically, and as shown in FIG. 13AA, one or more infrared lights 1232 may be mounted on or next to projector 1204, and may be aimed or configured so as to bathe the desired section of wall surface 1106 the projector 1204 is focused on, in infrared light 1231. Depending on how closely infrared light 1231 is located relative to projector 1204, the axis of the infrared beam may be angled relative to the projection beam so that their beams generally coincide over the desired section of wall surface 1106. The focal lengths of the infrared light beam and the projection beam may also coincide, though this is not necessary. In other embodiments, an infrared light 1232 and infrared camera need not be associated with each projector 1204.

[00112] The infrared light field 1231 on the wall is generally not visible to a person because wavelengths of infrared light are generally not perceptible to the human eye. As such, the infrared light 1231 does not interfere with the visual effects and/or overall appearance provided by display 1010 to the observer.

[00113] The infrared light 1231 that illuminates the desired section of wall 1106 will provide an infrared image 1236 for recording. For example, where the infrared light 1231 illuminates water flowing down the desired section of wall 1106, and where that water flows down in an aerated or turbulent manner, the infrared light 1231 will interact with that water and thereby provide an infrared image or footage 1236 that may be captured or recorded. As noted above, this infrared image 1236 is generally not visible to the human eye.

[00114] Infrared system 1230 may also include infrared camera 1234 which may record the infrared image 1236 resulting from, e.g., the infrared light interacting with the water flowing down wall 1106. Though the infrared image is generally not visible

to the observers' human eyes, infrared camera 1234 may "see" and record the infrared image 1236 on wall 1106 and whatever else is in its field that is illuminated by the infrared light 1231. As such, infrared camera 1234 may record captured infrared footage 1236, which may then be processed or altered to produce projected footage 1232 that is in the visible light spectrum and thus visible to observers. As discussed below, this footage 1236 that has been converted to from infrared to visible light may then be projected by projector 1204.

[00115] As noted previously, infrared camera 1234 may capture only those images/video resulting from the infrared light 1231 interacting with the delivered water (which images/video are not visible to observers), and not the images/video of the projected video 1202 (which images/video are visible to observers). As such, when the captured infrared footage 1236 is ultimately projected by projector 1204, after it has been altered as mentioned above and discussed further below, the projected footage 1232 is based only on the infrared footage 1236, and not visible light footage.

[00116] Infrared camera 1234 may be associated with the projector 1204. For example, infrared camera 1234 may be mounted to or located in proximity to projector 1204. Infrared camera 1234 is preferably focused on the same part of the wall 1106 that projector 1204 is focused on, so that the captured infrared footage 1236 is recorded from the same section of wall 1106 that the altered footage will be directed at by projector 1204.

[00117] As noted above, the captured infrared footage 1236 may be altered or modified so that it may ultimately be projected as converted/visible projected footage 1232 onto wall 1106. In general, this may occur by shifting the output of the infrared camera 1234 into the visible spectrum.

[00118] For example, the video signal from the infrared camera 1234 may be fed to a computer, such as controller 300 or central server 1300, that has been programmed to filter and/or modify the captured infrared footage 1236 so that it is useable for the next step, i.e., projecting converted/visible light footage 1232 onto the water flowing down wall 1106.

[00119] As discussed later in connection with FIGS. 19-20, software may be used to perform the various processing of the recorded infrared light en route to the projected image. This may generally be controlled by central server 1300.

[00120] The converted or processed infrared image may be used as an electronic mask or backdrop in any number of ways. For example, computer 300 may now lay “imagery” onto video frames, frame by frame, to provide an output that is routed to projector 1202 which may then project the (infrared-converted-to-visible-light) footage 1232 onto wall 1106. In a preferred embodiment, this converted footage 1232 may be the only signal the projector 1202 is getting, so if there is nothing being fed from the content creation computer 300, the projector is “dark”.

[00121] Where the infrared-converted-to-visible light signal is the only input feeding projector 1202, so that the only image projected on wall 1106 is the infrared-converted-to-visible light projected footage 1232, unique visual effects may be achieved. This is because that footage will be derived only from the captured infrared footage 1236 (that the observer cannot see) and not also the captured footage 1208 that would otherwise be based on the visible light projected image 1220 (that the observer can see). In other words, the ultimate visual effect that is visible to the observer is an image or footage that is initially invisible to the observer.

[00122] The manner in which display 1010 uses flowing water and infrared system 1230 to create visual effects is now further described. In a preferred embodiment, the process of providing the visual effects to observers may represent a “loop” that starts when a volume of water is pushed up and over the top edge 1120 of the wall, cascading down the textured face or wall 1106, and becoming turbulent or aerated as it flows downward. This aeration may generally make the water visible, because ambient light interacting with the water will generally be reflected off the water in gray to white wavelengths, depending on the volume, velocity and/or other characteristics of water flowing down the wall for this particular “wave.”

[00123] Generally, as shown in FIG. 20 the leading edge of the downwardly flowing water, or wave, is relatively more turbulent, and as such, will reflect significant infrared light 1231 for recording by the infrared camera 1234. The wave may be less turbulent away from the leading edge and thus fade regarding the amount of infrared light it reflects. Where there is no wave and the wall 1106 is exposed to the infrared light 1231, very little or no reflection may occur. In a preferred embodiment, the walls 1106 over which the delivered water 1102 flows, may be illuminated by infrared light 1231, which is not visible to a person. This live image of water rushing down the face of the wall may be received by the processing computer and new video may be

generated live that will be projected onto or “paint” the wave as it rushes down the wall 1106. Any other content desired as part of the overall display may also be added. For example, the projected content can also happen in the negative space.

[00124] The process of recording reflected infrared light, processing the digital representation of this recorded infrared light and creating a visible light projection preferably occurs quickly so that the projected visible light may be projected onto the wave in generally real time. For example, this may occur in about three frames of recording and video projection.

[00125] The visual effects provided by display 1010 are now further described with reference to FIGS. 17A-17AAAA which comprise a series of still shots from a video showing display 1010 during the daytime, and FIGS. 18A-18XXX which comprise a series of still shots from a video showing display 1010 during the nighttime. In both series of still shots, the color being projected on the delivered water 1102 or the wave(s) as they rush down the wall 1106 is preferably generated on the fly in the processing computer 300, 1300 to paint the wave(s) 1106 by way of infrared-converted-to-visible-light video output to, and projected from, the projector 1204.

[00126] Starting with the daytime still shots, FIG. 17A shows a generally steady state stream of water 1102 flowing down wall 1106. However, this visual effect may be the result of previously recorded footage of water flowing down wall 1106, which may then be projected. As such, the appearance shown in FIG. 17A may be displayed even without water actually flowing down wall 1106. Alternatively, water 1102 may actually flow down wall 1106 and be illuminated by the video from projector 1204. As noted at the outset, the appearance of velocity at which water 1102 flows down wall 1102 in this steady state may generally condition the observer’s perception or brain to what appears to be an expected velocity rate for downward flowing water. It should be noted that the daytime sequence of still shots is provided primarily as a reference point for the night time sequence of still shots described later. Generally, it is preferred that the choreography of the display of the current inventions is performed at night, because sunlight occurring during the day time may overpower any projected images. However, as the daytime progresses to dusk, the overall display may provide the visual effects described herein.

[00127] Starting with FIG. 17B, and continuing through FIG. 17F, a volume of water 1102 may then be pushed up and over the top edge 1120 of wall 1106. For example, water 1102 may be pushed out of one or more boxes 1104 (as shown in FIG. 13) and over top edge 1120. The surface 1106 of wall may be black to facilitate capturing infrared footage 1236. Surface 1106 may also be textured so that the water 1102 flowing down becomes aerated; thus assuming a white to gray color, depending on the volume of water 1102 flowing down surface 1106. This in turn makes water 1102 more susceptible to interacting with the infrared light 1231 that is bathing or illuminating water 1102. That is, more infrared light will be reflected from the white to gray colors of water 1102, than the infrared light reflected from black wall 1106. As such, the live infrared footage 1236 being captured by the infrared camera 1234 generally reflects the water 1106 flowing downward. And as noted above, the infrared light is not visible to the observers of display 1010.

[00128] As mentioned above, the live infrared footage is transmitted to controller 300, or central server or computer 1300 for processing, e.g., conversion from infrared light to visible light to be input into projector 1204. To this end, the recorded infrared light is digitized, e.g., where each pixel is assigned a color value according to the gray scale value of the recorded infrared light. The processing speed of computer 1300 is preferably sufficiently fast, e.g., output a new 8000 x 1920 video frame 60 times per second. This preferably occurs for each single screen (or segment or section) of wall 1106 from which infrared footage is captured, then converted, and then projected as visible light. To this end, each wall 1106 may be considered a single screen for output purposes, with seven screens that are stitched together, e.g., 1200 x 1920 pixels in portrait per projector, multiplied by seven (7) minus a bit on the 1200 edge for overlap.

[00129] The processing speed of computer 300 has resulted in the innovative software features as described above. The resulting process speed provided by computer 300 has made a fast frame rate possible to avoid latency, i.e., late frames of video, which would become obvious with more than approximately 4 or 5 frames latency.

[00130] The converted infrared footage is then projected onto water 1102 in real time. However, the speed at which this footage is projected may be varied to provide the visual effect that the water is flowing downward more slowly than it should be, according to the observer's perception, i.e., according to the observer's brain's

expectation. For example, as shown in FIGS. 17B-17F the water 1102 flowing down wall 1106 may appear to be flowing more slowly than it “should.”

[00131] FIGS. 17G-17L show another sequence of still shots where the water is released from right to left. The manner in which display 1010 may be generated may be similar as described in connection with FIGS. 17B-17F.

[00132] FIGS. 17M-17P show another sequence of still shots where the water is released from left to right, and FIGS. 17Q-17T show another sequence of still shots where the water is released from right to left.

[00133] The visual effects that may be provided by display 1010 during the night time is now further described with reference to the still shots of FIGS. 18A-18XXX. Display 1010 is preferably performed at night and may involve pushing waves of water in a programmed sequence over the edge of wall 1106. It should be noted that the sequence of still shots shown is merely one example of the choreography that may be shown by the overall display. Waves of water may be shown to be suspended in mid-air, slowing down, speeding up, reversing course and ascending, traveling sideways, etc. Furthermore, other visual effects may be added to the display. For example, several starfish, shells or other items that may be found on a beach may be displayed on wall 1106, and may then be swept away by a wave of delivered water. Still further, various colors, music and other audio/visual effects may be included in the overall display.

[00134] Referring again to the process of recording, processing and projecting, the water flowing down the wall may be illuminated with infrared light 1231, invisible to observers, but recorded by infrared camera 1234. Infrared camera 1234 preferably captures/records infrared footage 1236 at more than 60 frames a second. However, other frame rates may be used.

[00135] The captured infrared footage 126 thereby provides a running real time image of the wall to the processing computers 300. Computer(s) 300 may process the incoming frames of captured infrared footage 1236 as masks, mats or whatever other form is desired to program the timeline as called for by that frame. To this end, computer(s) 300 may generate a video image that is ultimately projected to wall 1106 by using various custom algorithms, filters, and content samples that will put a visible-light video projection on the wave in whatever the programmer has set it to do (for that

frame). This may be programmed beforehand not knowing where the waves may actually be when they flow downward, their velocity, opacity or behavior. As such, it is preferred that the recording processing and projection of images is processed and output live. As discuss later, this process may be aided by predicting where the wave may be as it flows downward.

[00136] For example, a frame of captured infrared footage 126 may be processed and output to projector 1204 for projection 1202 on the water 1102 flowing down wall 1106. As such, one frame has been output to the projectors; this is preferably followed by the processing and outputting of additional frames at about 60 frames per second.

[00137] The overall appearance of display 1010 of the current inventions is now further described. Controller or server 300 may stitch together screens of captured infrared footage from individual sections of wall 1106. This stitched together footage may then be coordinated to be projected at the desired wall 1106.

[00138] Plaza with walk through and different features and stairs and different observation points; this could be a destination in and of itself or a significant portion of a theme park, etc. The display may generally reside below surface level so that outside of the display, the walls of the structures forming walls 1106 may not be excessively tall. As such, when observers enter the display, they may walk down stairs and may be below ground level when walking around the plaza and being surrounded by, and immersed in, the audio and visual effects provided by the display.

[00139] Referring to FIG. 15, additional aspects of the projectors 1204 are described. As shown, projector 1204 may reside within the structure 1108 which forms wall 1106. This may be preferred so that the hardware associated with projectors 1204 are kept hidden from view of the observers. When configured in this manner, the image emitted from projectors 1204 may be redirected by mirrors that are positioned on top of structures 1108. The projected image may then be directed towards walls 1106. The arrows in FIG. 15 also show airflow which may be directed towards the projector 1204 to cool it.

[00140] The recording, processing and projecting of infrared light and visible light images is now further described with reference to the process 1900 shown in FIG. 19.

Process 1900 is described with reference to a series of frames taken at different steps along the way.

[00141] As shown, in frame 1910, infrared light that is reflected from the water flowing down wall 1106, or reflected off the wall 1106 itself – which may be black - may first be recorded. The color values for each pixel may then be adjusted as shown in frame 1920. The representation may then be processed by predictive wave adjustments as shown in frame 1930. These adjustments may be based on data associated with prior waves emitted under certain circumstances, e.g., how much pressurized air is applied to the water in the boxes 1104 before the water is released. Based on data regarding how the wave proceeds down wall 1106 for a set of circumstances, the representation may be processed in frame 1930 to reflect the prediction where the wave will go and how fast it will go.

[00142] As shown in frame 1940, software may be used to create a wave mask. This may occur, for example, where brightness values are adjusted to account for the location on wall 1106 (and associated curvature of the wall at that location) on which the projected image appears. As shown in frame 1940, shadows may then be generated and added to the representation. For example, the wave may be made to appear that it is separated from wall 1006 by adding a shadow that would exist if the wave was actually so separated. Further masking may occur as in frame 1960, and the representation may then be layered with other wave as shown in frame 1970.

[00143] At this point, the processed representation may be converted into visible light and emitted from the projectors as the projection image shown in frame 1980. As noted earlier, the projected image may include various colors and visual effects other than those shown in process 1900.

[00144] The visual effect whereby a wave is shown to reverse course and ascend up the wall 1106 is now further described with reference to process 1990 of FIG. 19. As shown in frame 1992, the image of waveforms may first be projected onto the flowing water. The projected image of the continued downward flow of the waveform may continue to be shown as in frame 1994. That is, as the actual water continues to flow down wall 1106, and infrared recordings are made and processed into visible light projections, these visible light projections may continue to be projected onto the wave as it flows downward.

[00145] However, as shown in frame 1996, while the actual water may continue to flow down the wall 1106, an image that was processed at a time when the wave was further up the wall 1106 may be projected onto the downward flowing water. At this point, the projection image is not being projected onto the leading edge of the wave as it had been previously as in frames 1992, 1994. Instead, the projected image is projected onto water above the leading edge of the wave but shows the leading edge higher up along wall 1106 than it actually is. The resulting visual effect is that the wave appears to be ascending.

[00146] The overall process in which the display may operate is now further described with reference to process 2000 of FIG. 20, which shows the relationships between the release of water 1102 down wall 1106, along with the infrared illumination and recording devices 1231, 1234 and projector 1204, along with the steps 2010 performed by video server 1300 and the steps 2040 performed by the show control server.

[00147] The show control server may generally perform certain tasks that relate to the overall choreography of the performance. For example, the show control server may first receive a play show command 2042 that will alert the display of the upcoming performance. This may be followed by a pre-show setup 2044 that may initialize and/or sync various components of the display. For example, this setup step 2044 may cause infrared light being emitted from the infrared light sources 1231 to illuminate wall 1106. This may be followed by step 2046 where audio, video, water controls and/or other features or effects of the performance may be synched. When this has occurred, the show control server may then transmit a signal 2048 to the water control to trigger a water expression. For example, this signal may release compressed air into boxes 1104 at the tops of walls 1106 to deliver water 1102 so that it may flow downward.

[00148] As the water 1102 flows down wall 1106, and as discussed above, infrared camera 1234 may record the infrared light that is reflected off the flowing water and/or the bare wall 1106. This recorded image may then be transmitted to the processing steps 2010.

[00149] First, as shown in step 1012, the infrared image may be received from the infrared camera. This image may be digitized. The infrared video data may then

be processed as in step 2014. The wave or water movement prediction may be added as in step 2016. The prediction may be based on how the water is initially delivered to the wall 1106, e.g., under how much pressure of compressed air. The prediction may also be based on tracking the leading edge of previous similar waves.

[00150] At this point, a software mask may be created from the infrared video data as in step 2018. This may involve receiving prerecorded video content from the video server 1300 as shown in step 2020, as well as digitally manipulating the infrared video data as shown in step 2022. The prerecorded video content (as well as audio content) may be stored in a library to be accessed as desired.) The prerecorded video content may be mixed with the digitally manipulated infrared video data. For example, certain prerecorded effects may be at the ready when water is released down wall 1106 under certain circumstances. That is, such prerecorded effects may be suitable for water released in a particular manner. Alternatively, the prerecorded content need not be used.

[00151] If there is mixing of prerecorded and digitally manipulated infrared data, a composite video may then be obtained as in step 2024. This video data may then be warped to map the data (and ultimately the projected image) to the desired geometry to be featured as in step 2026. The output video may then be obtained as in step 2028 for transmitting to projector 1204. The projector 1204 may then project the visible light image onto wall 1106.

[00152] It is preferred that the processing steps 2010 occur sufficiently fast so that the projected images may be projected onto the flowing water in real time or near real time. In a preferred embodiment, this processing occurs within three frames.

[00153] It is understood by a person of ordinary skill in the art, upon reading this specification, that the examples described above are meant for demonstration, that the system **10** may include the same, similar or different functionalities as those described, and that the scope of the of the system **10** is not limited in any way by the disclosed examples. It is also understood that any of the embodiments and/or examples of the system **10**, described or otherwise, may be combined in any way. It is also understood that while the above examples described the system **10** with respect to altering the visual appearance of moving liquid (e.g., water), the system **10** may alter the visual appearance of any type of physical forms including solids, liquids,

gasses, and any combination thereof, and that the scope of the system **10** is not limited in any way by the types of physical forms it may visually alter.

[00154] Those of ordinary skill in the art will appreciate and understand, upon reading this description, that embodiments hereof may provide different and/or additional advantages, and that not all embodiments or implementations need have all advantages.

[00155] A person of ordinary skill in the art will understand, that any method described above or below and/or claimed and described as a sequence of steps is not restrictive in the sense of the order of steps.

[00156] Where a process is described herein, those of ordinary skill in the art will appreciate that the process may operate without any user intervention. In another embodiment, the process includes some human intervention (e.g., a step is performed by or with the assistance of a human).

[00157] As used herein, including in the claims, the phrase “at least some” means “one or more,” and includes the case of only one. Thus, e.g., the phrase “at least some ABCs” means “one or more ABCs”, and includes the case of only one ABC.

[00158] As used herein, including in the claims, term “at least one” should be understood as meaning “one or more”, and therefore includes both embodiments that include one or multiple components. Furthermore, dependent claims that refer to independent claims that describe features with “at least one” have the same meaning, both when the feature is referred to as “the” and “the at least one”.

[00159] As used in this description, the term “portion” means some or all. So, for example, “A portion of X” may include some of “X” or all of “X”. In the context of a conversation, the term “portion” means some or all of the conversation.

[00160] As used herein, including in the claims, the phrase “using” means “using at least,” and is not exclusive. Thus, e.g., the phrase “using X” means “using at least X.” Unless specifically stated by use of the word “only”, the phrase “using X” does not mean “using only X.”

[00161] As used herein, including in the claims, the phrase “based on” means “based in part on” or “based, at least in part, on,” and is not exclusive. Thus, e.g., the phrase “based on factor X” means “based in part on factor X” or “based, at least in

part, on factor X.” Unless specifically stated by use of the word “only”, the phrase “based on X” does not mean “based only on X.”

[00162] In general, as used herein, including in the claims, unless the word “only” is specifically used in a phrase, it should not be read into that phrase.

[00163] As used herein, including in the claims, the phrase “distinct” means “at least partially distinct.” Unless specifically stated, distinct does not mean fully distinct. Thus, e.g., the phrase, “X is distinct from Y” means that “X is at least partially distinct from Y,” and does not mean that “X is fully distinct from Y.” Thus, as used herein, including in the claims, the phrase “X is distinct from Y” means that X differs from Y in at least some way.

[00164] It should be appreciated that the words “first,” “second,” and so on, in the description and claims, are used to distinguish or identify, and not to show a serial or numerical limitation. Similarly, letter labels (e.g., “(A)”, “(B)”, “(C)”, and so on, or “(a)”, “(b)”, and so on) and/or numbers (e.g., “(i)”, “(ii)”, and so on) are used to assist in readability and to help distinguish and / or identify, and are not intended to be otherwise limiting or to impose or imply any serial or numerical limitations or orderings. Similarly, words such as “particular,” “specific,” “certain,” and “given,” in the description and claims, if used, are to distinguish or identify, and are not intended to be otherwise limiting.

[00165] As used herein, including in the claims, the terms “multiple” and “plurality” mean “two or more,” and include the case of “two.” Thus, e.g., the phrase “multiple ABCs,” means “two or more ABCs,” and includes “two ABCs.” Similarly, e.g., the phrase “multiple PQRs,” means “two or more PQRs,” and includes “two PQRs.”

[00166] The present invention also covers the exact terms, features, values and ranges, etc. in case these terms, features, values and ranges etc. are used in conjunction with terms such as about, around, generally, substantially, essentially, at least etc. (i.e., “about 3” or “approximately 3” shall also cover exactly 3 or “substantially constant” shall also cover exactly constant).

[00167] As used herein, including in the claims, singular forms of terms are to be construed as also including the plural form and vice versa, unless the context indicates otherwise. Thus, it should be noted that as used herein, the singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise.

[00168] Throughout the description and claims, the terms “comprise”, “including”, “having”, and “contain” and their variations should be understood as meaning “including but not limited to”, and are not intended to exclude other components unless specifically so stated.

[00169] It will be appreciated that variations to the embodiments of the invention can be made while still falling within the scope of the invention. Alternative features serving the same, equivalent or similar purpose can replace features disclosed in the specification, unless stated otherwise. Thus, unless stated otherwise, each feature disclosed represents one example of a generic series of equivalent or similar features.

[00170] The present invention also covers the exact terms, features, values and ranges, etc. in case these terms, features, values and ranges etc. are used in conjunction with terms such as about, around, generally, substantially, essentially, at least etc. (i.e., “about 3” shall also cover exactly 3 or “substantially constant” shall also cover exactly constant).

[00171] Use of exemplary language, such as “for instance”, “such as”, “for example” (“e.g.”) and the like, is merely intended to better illustrate the invention and does not indicate a limitation on the scope of the invention unless specifically so claimed.

[00172] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. A method of altering the visual appearance of a moving physical form, the method comprising:

(A) capturing video footage of the moving physical form;

(B) altering a first portion of the captured video footage to create a first altered video sequence; and

(C) projecting the first altered video sequence onto the moving physical form.

2. The method of claim 1 further comprising:

(D) altering a second portion of the captured video footage to create a second altered video sequence; and

(E) projecting the second altered video sequence onto the moving physical form.

3. The method of claim 1 wherein the moving physical form is selected from the group: gas, sand, pebbles, balls and water.

4. The method of claim 1 wherein the altering a first portion of the captured video footage in (B) includes decreasing the playback speed of at least a portion of the captured video footage or increasing the playback speed of at least a portion of the captured video footage.

5. The method of claim 1 wherein the altering of the first portion of the captured video footage in (B) includes altering the orientation of the captured video footage.

6. The method of claim 1 wherein the moving physical form is selected from the group: water droplets falling through the air, water flowing down a structure, a parabolic water stream, and a water spray.

7. The method of claim 1 wherein the altering a first portion of the captured video footage in (B) is performed by a controller.

8. The method of claim 1 wherein the capturing of video footage in (A) is performed by one or more video cameras.

9. The method of claim 1 wherein the projecting the first altered video sequence in (C) is performed by one or more video projectors.

10. A system for altering the appearance of moving water, the system comprising:

at least one video capturing device for capturing video footage of the moving water;

a controller for altering the captured video footage; and

at least one video projecting device for projecting the altered video footage onto the moving water;

wherein the at least one video capturing device captures video footage of the moving water, the controller alters at least a portion of the captured video footage, and the at least one video projecting device projects at least a portion of the altered portion of video footage onto at least a portion of the moving water.

11. The system of claim 10 wherein the controller alters at least a portion of the captured video footage by decreasing the playback speed of the at least a portion of the captured video footage, by increasing the playback speed of the at least a portion of the captured video footage, or by altering the orientation of the at least a portion of the captured video footage.

12. The system of claim 10 wherein the moving water is selected from the group: water droplets falling through the air, water flowing down a structure, a parabolic water stream, and a water spray.

13. The system of claim 10 wherein the at least one video capturing device includes a visible light video camera or a non-visible light video camera.

14. The system of claim 10 wherein the video capturing device is a digital or analog video camera.

FIG. 2

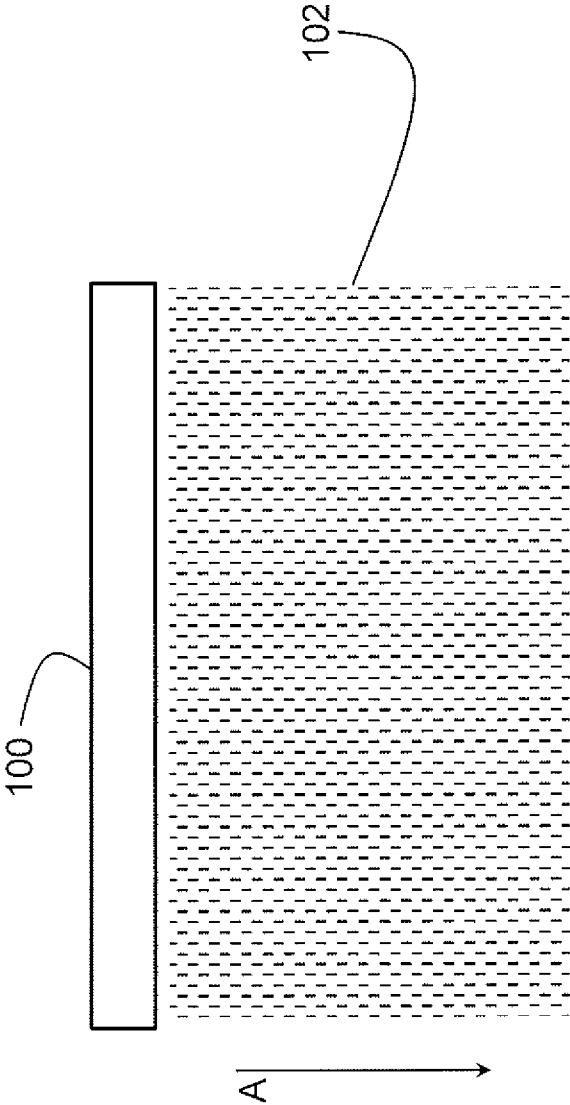


FIG. 3

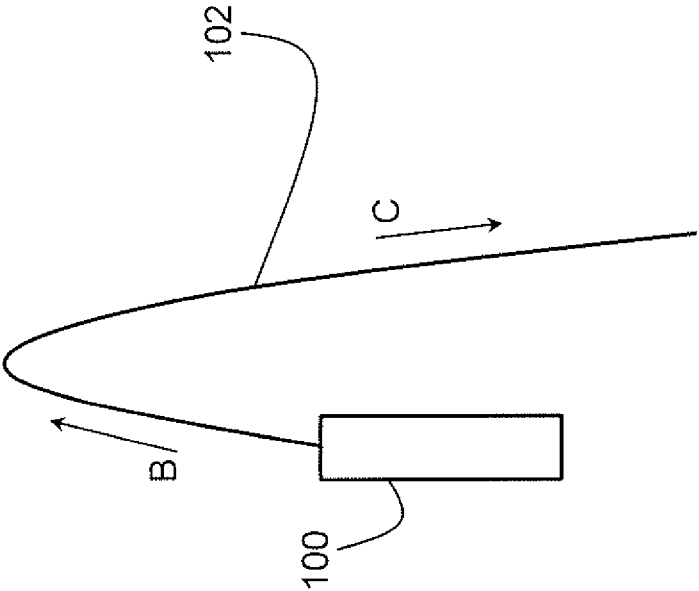


FIG. 4

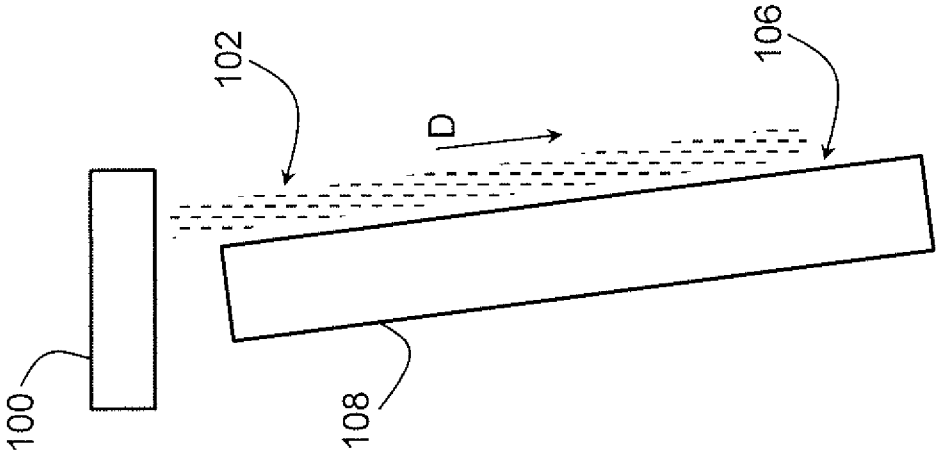


FIG. 5

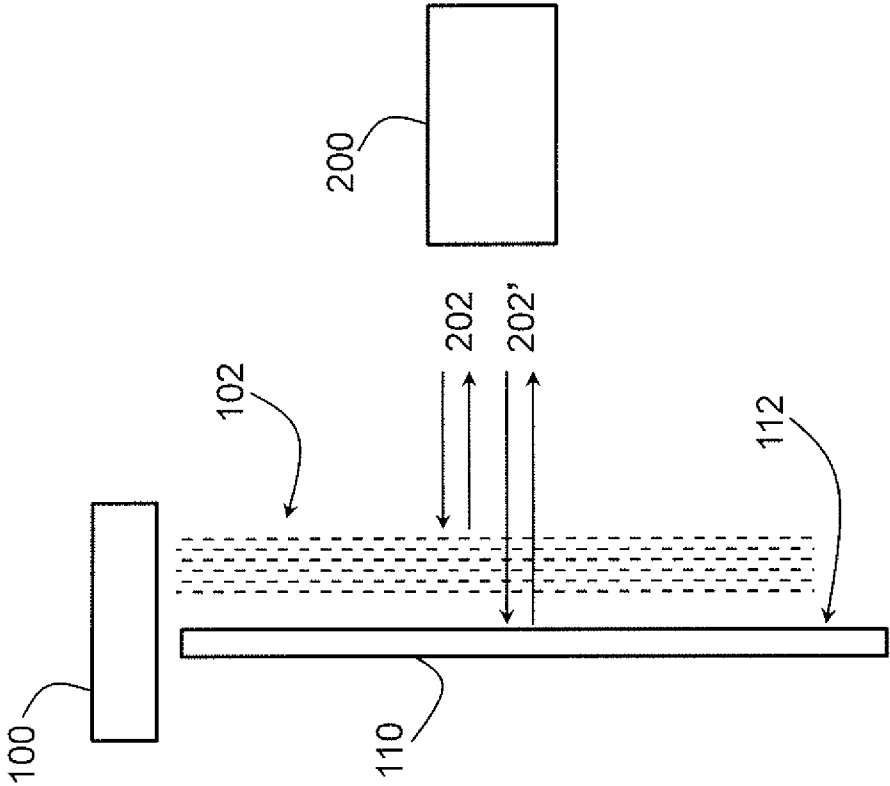


FIG. 6

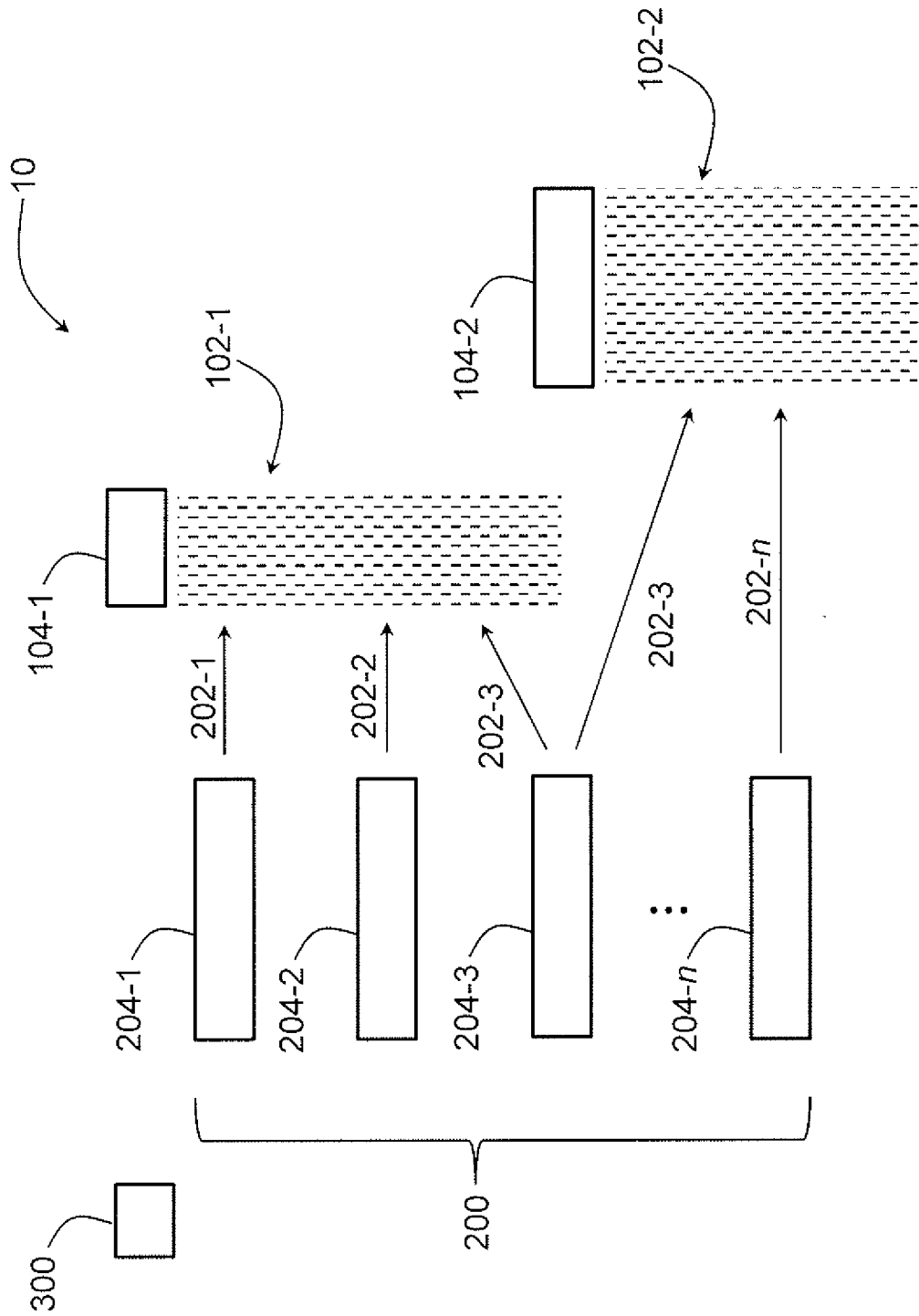


FIG. 7

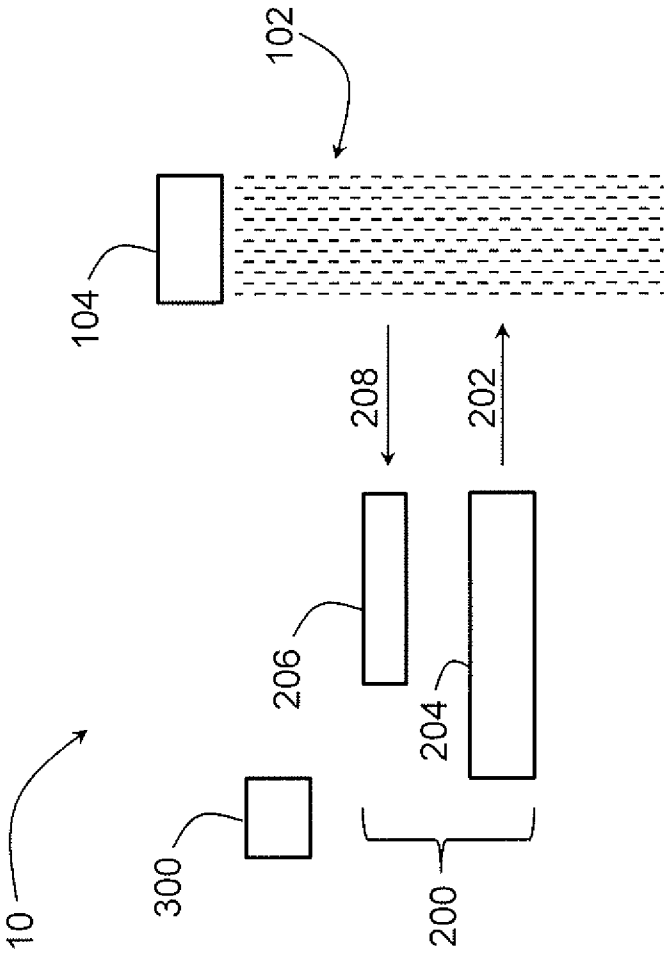


FIG. 8

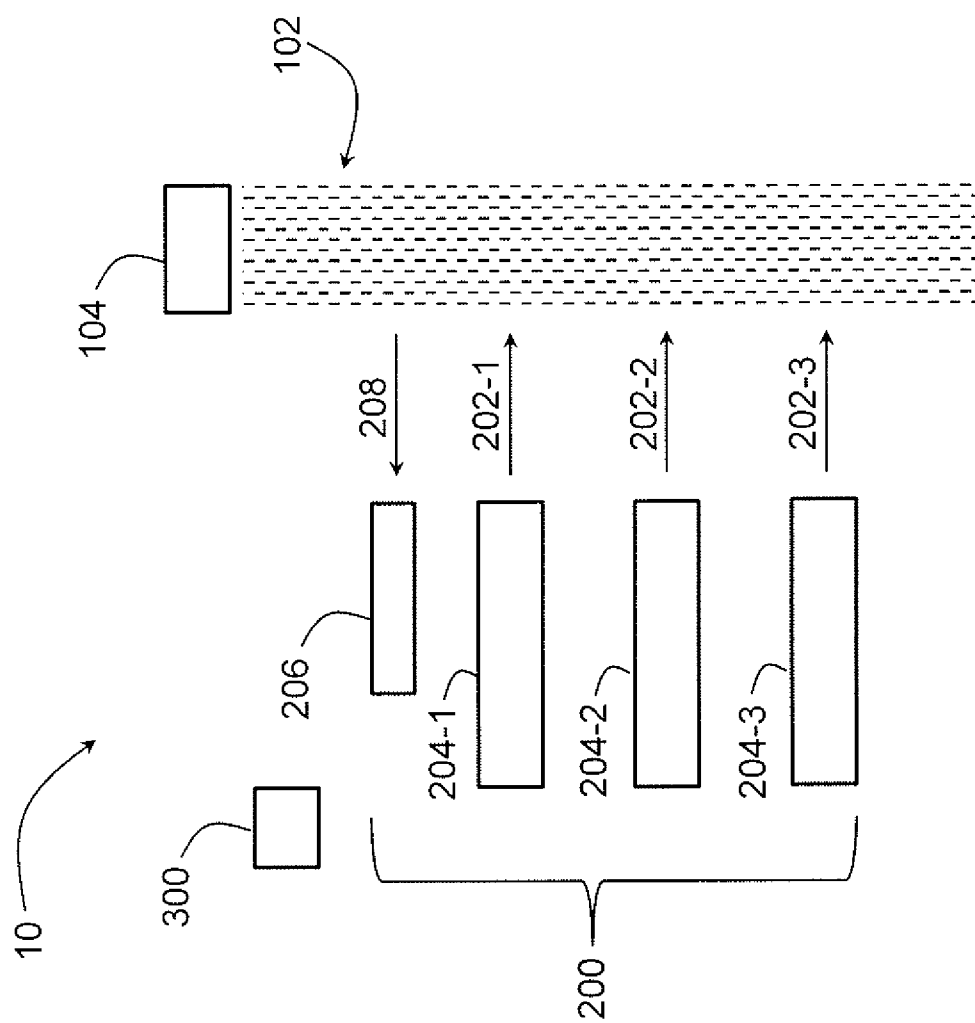


FIGURE 9



FIGURE 10

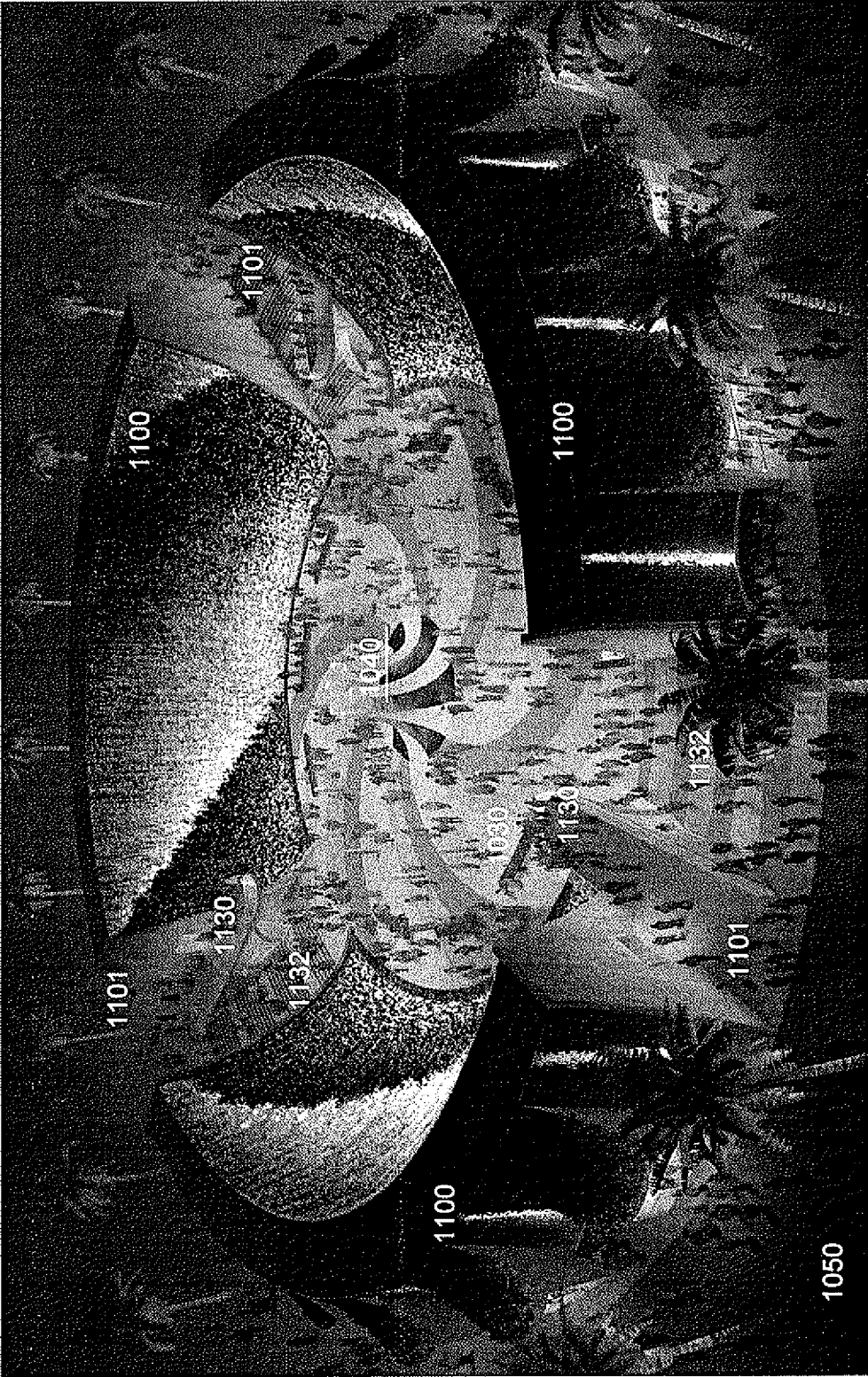


FIGURE 11

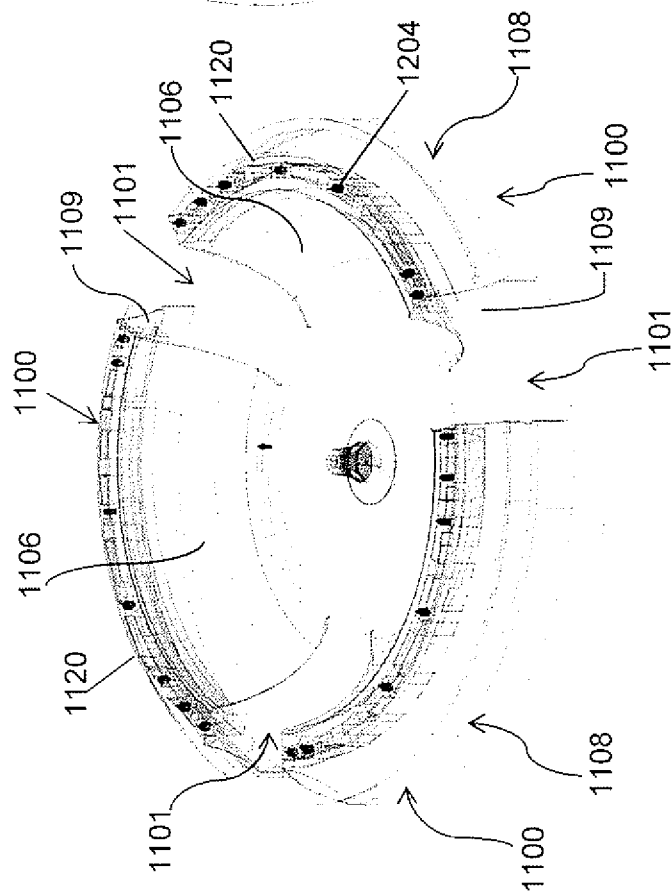


FIGURE 12

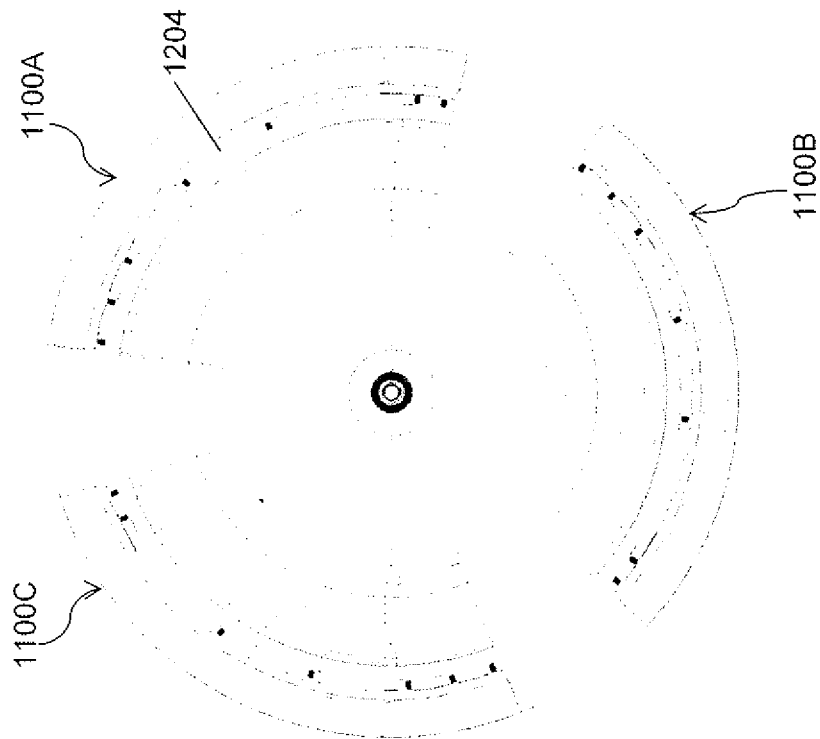
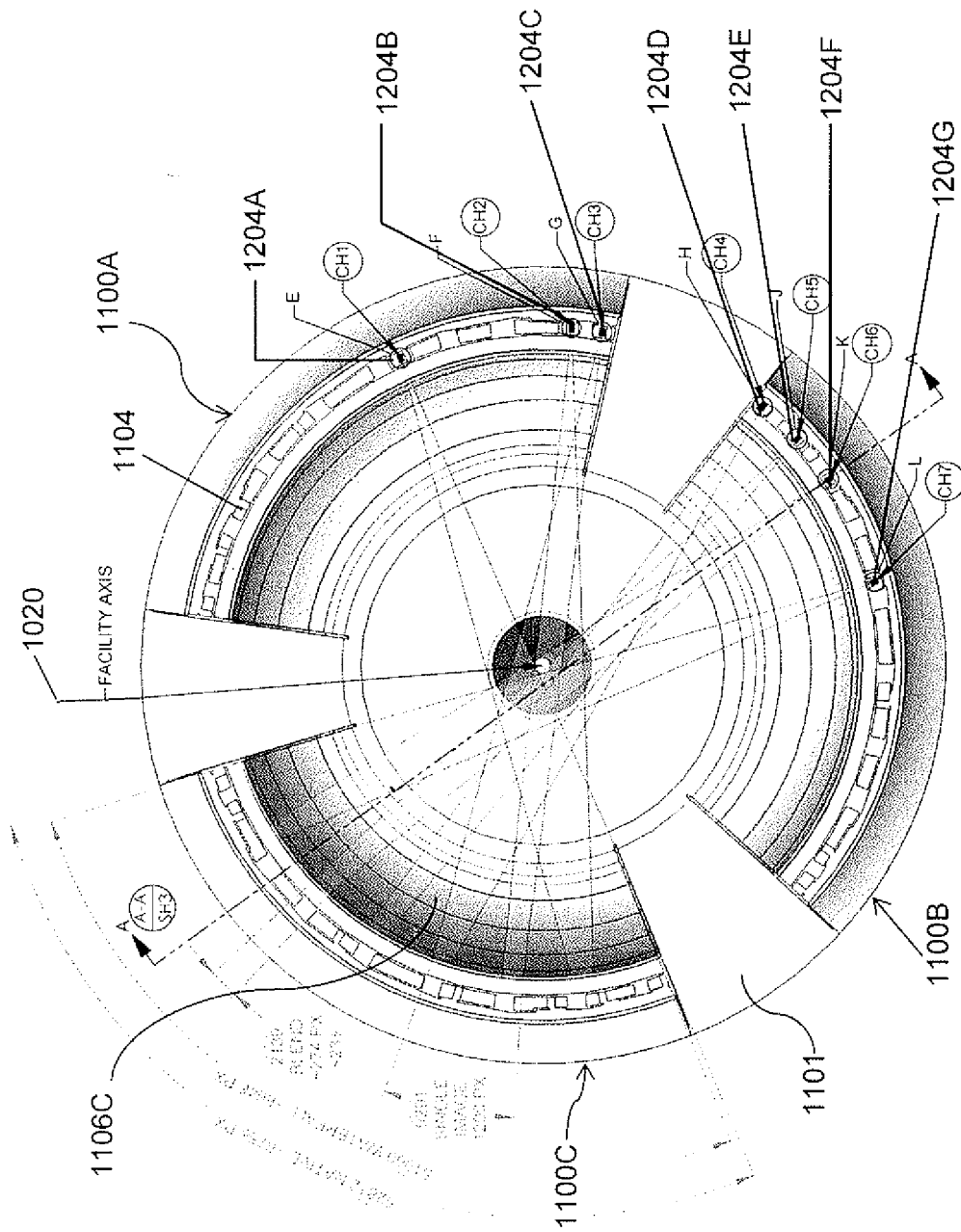


FIGURE 13



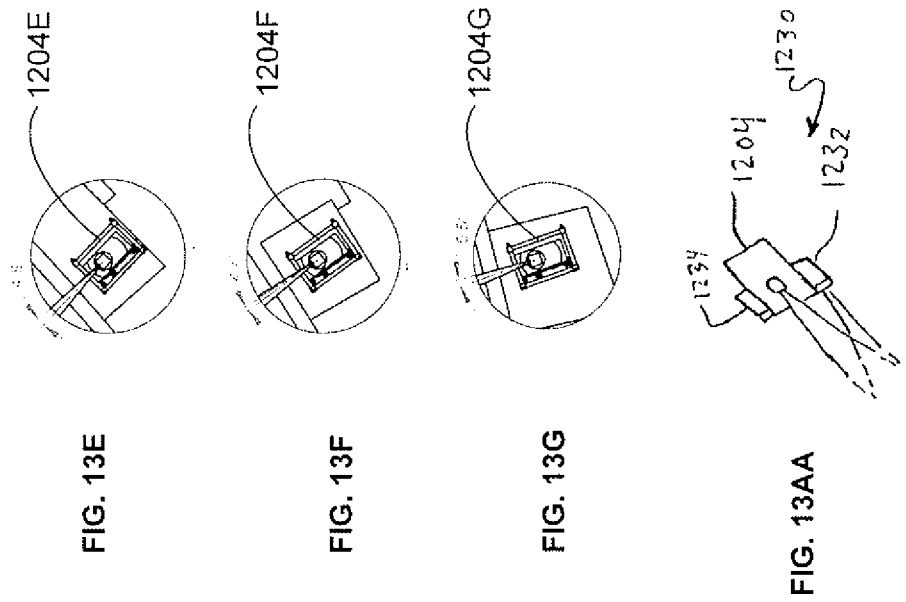
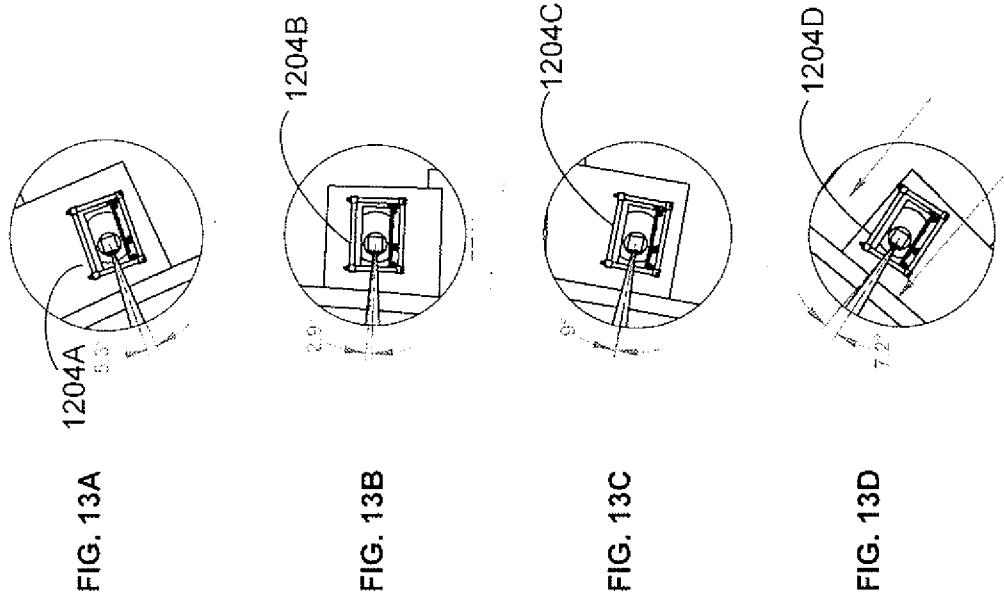


FIGURE 14

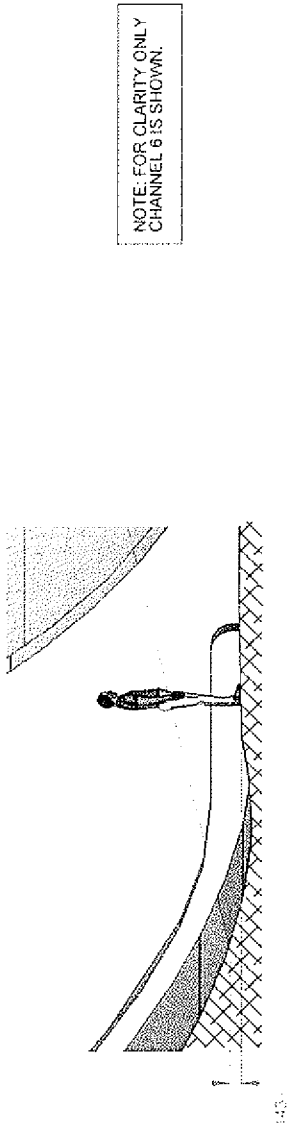
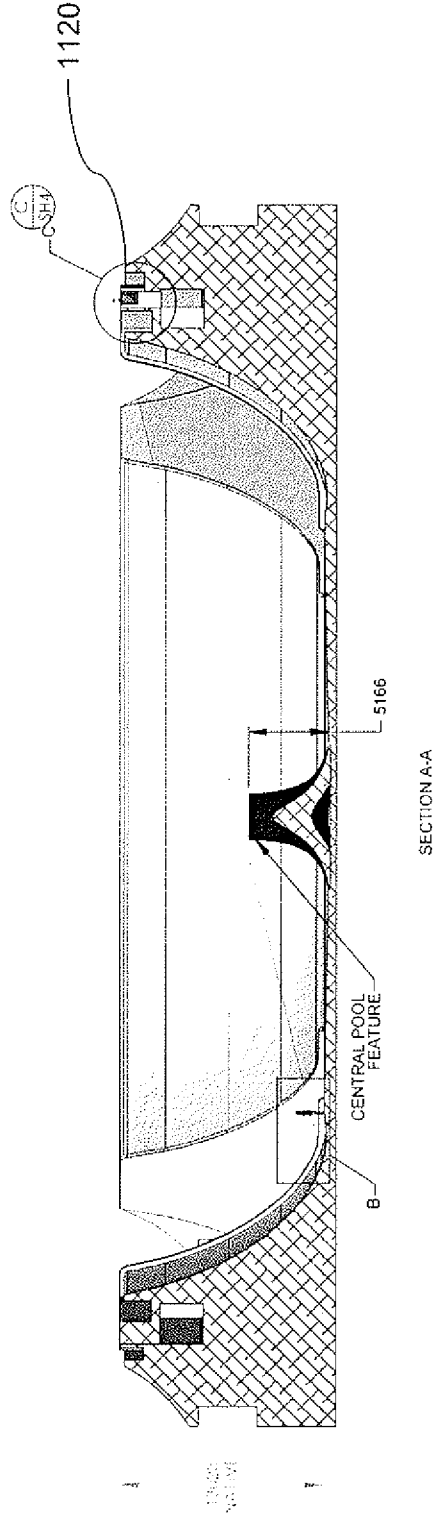


FIGURE 14A

FIGURE 15

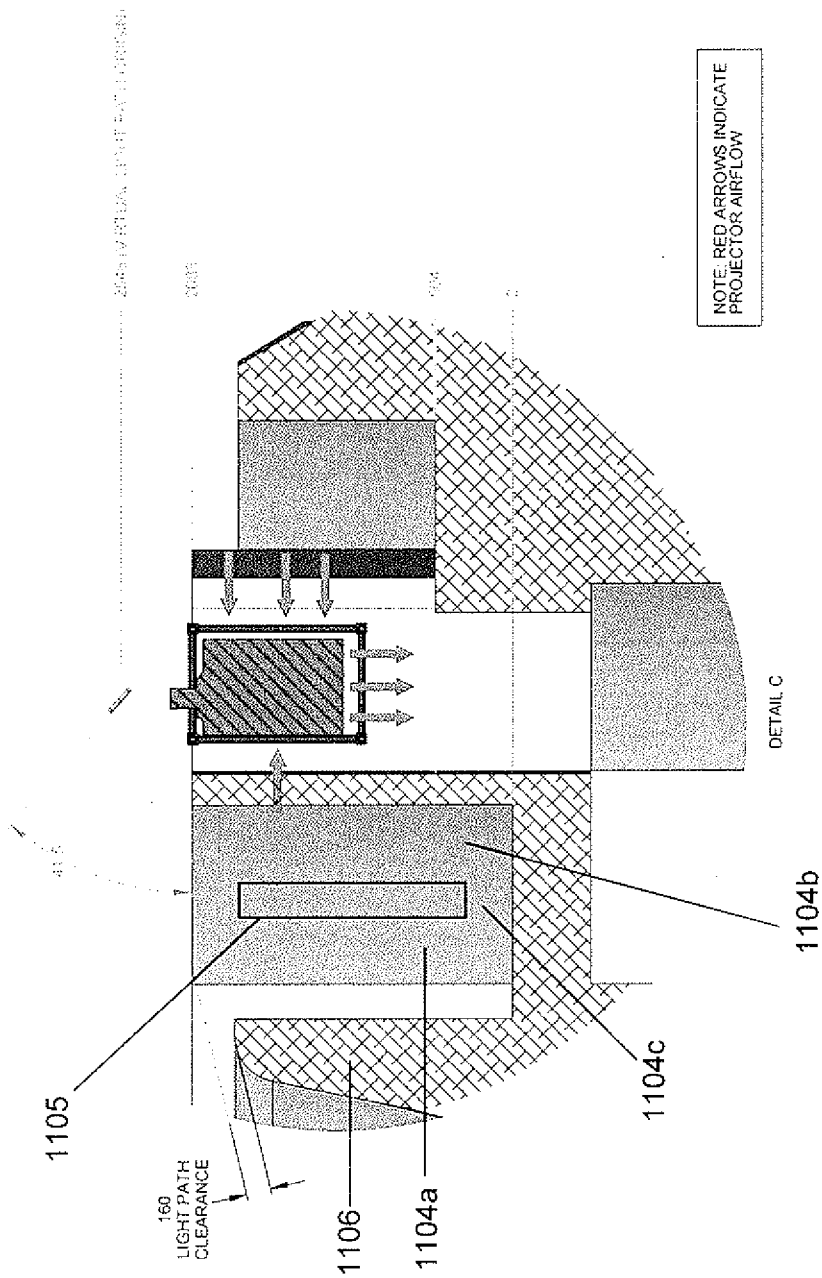
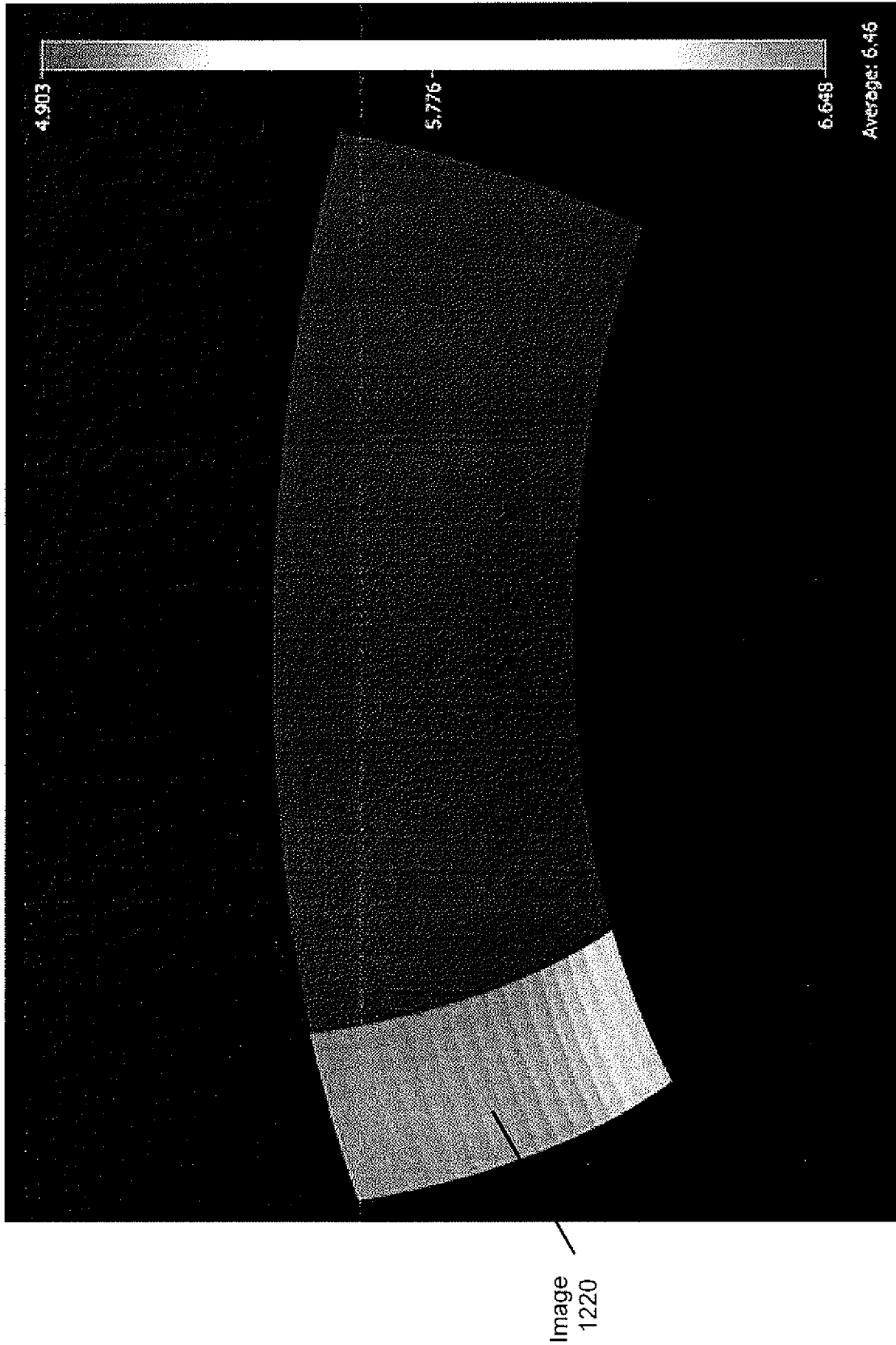


FIGURE 16



WET – Stills of Video 10-04-19 121157

00:04

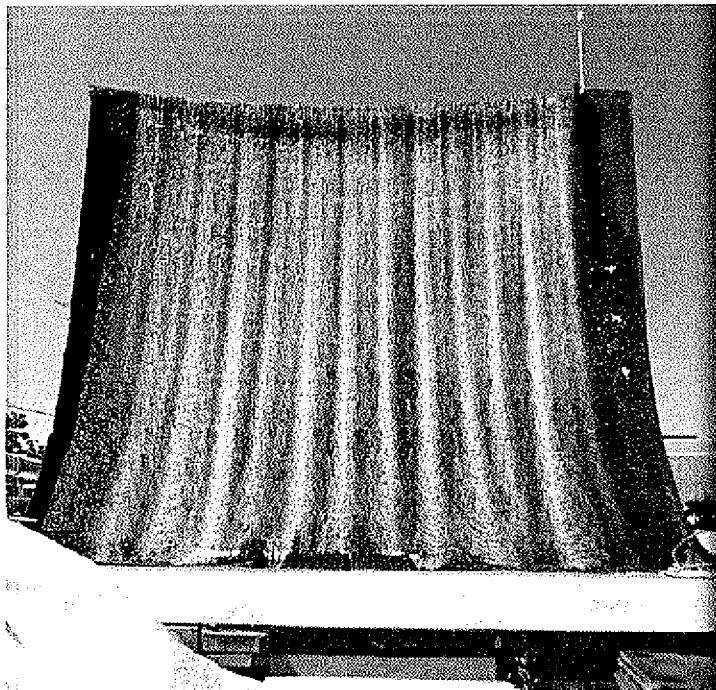


FIGURE 17A

00:16

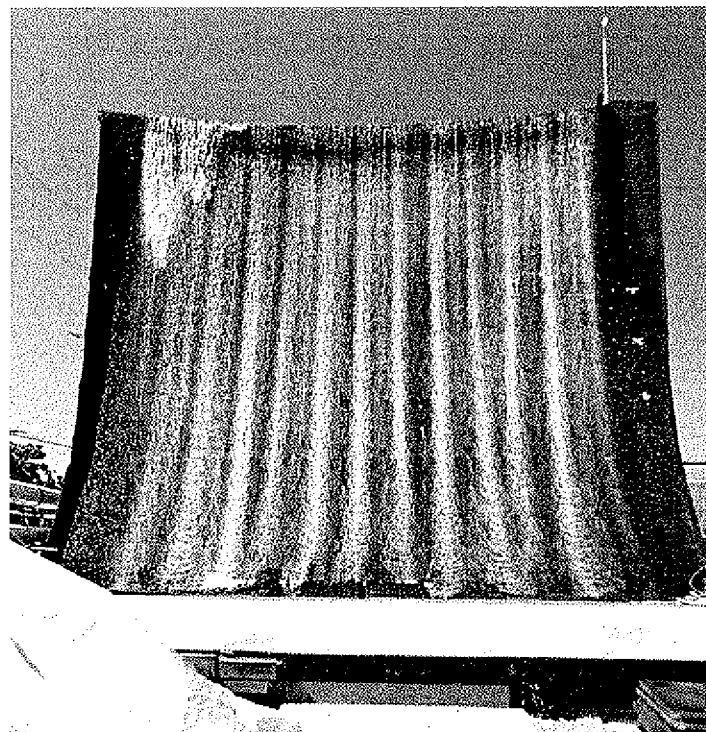


FIGURE 17B

00:18



FIGURE 17C

00:20

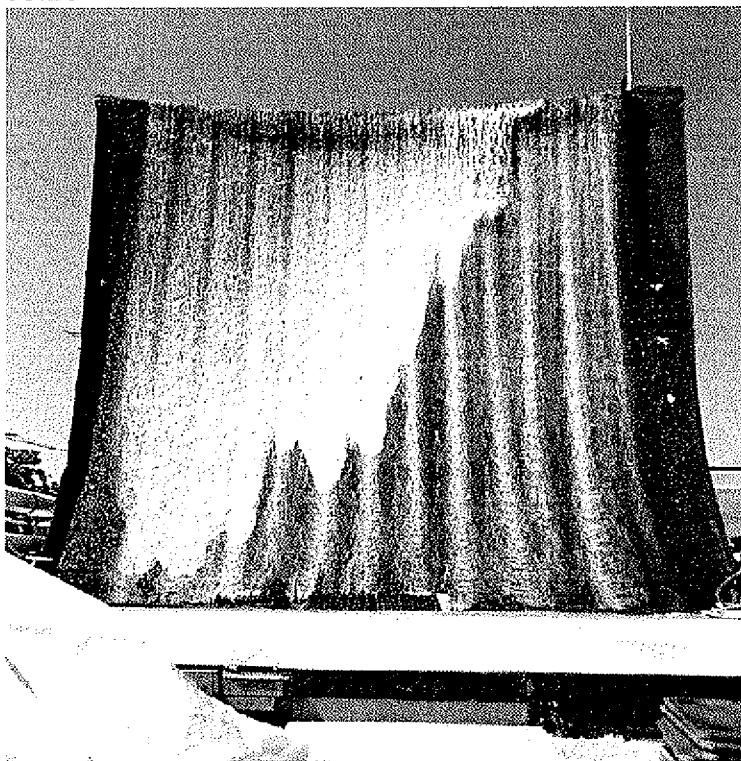


FIGURE 17D

00:23



FIGURE 17E

00:25

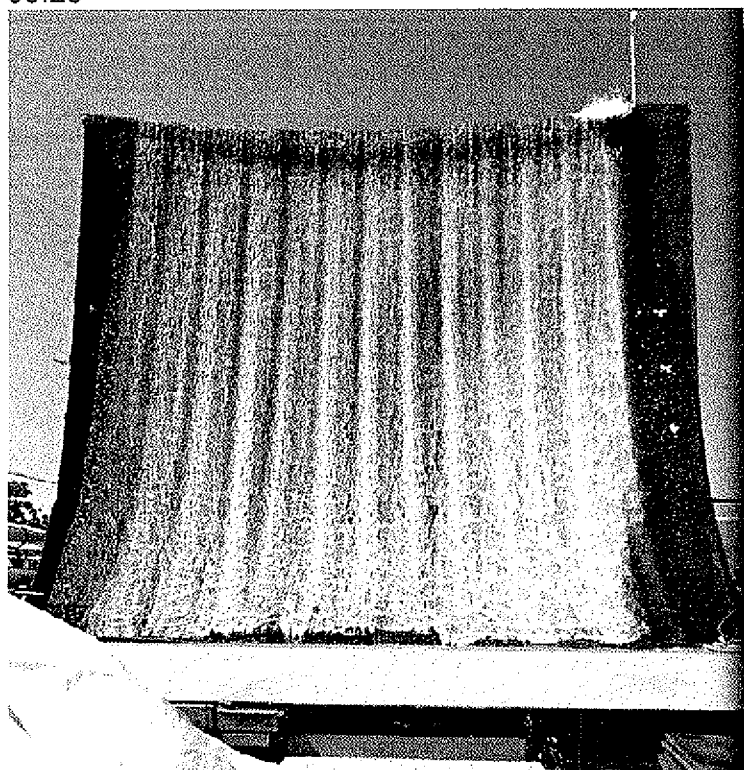


FIGURE 17F

00:26

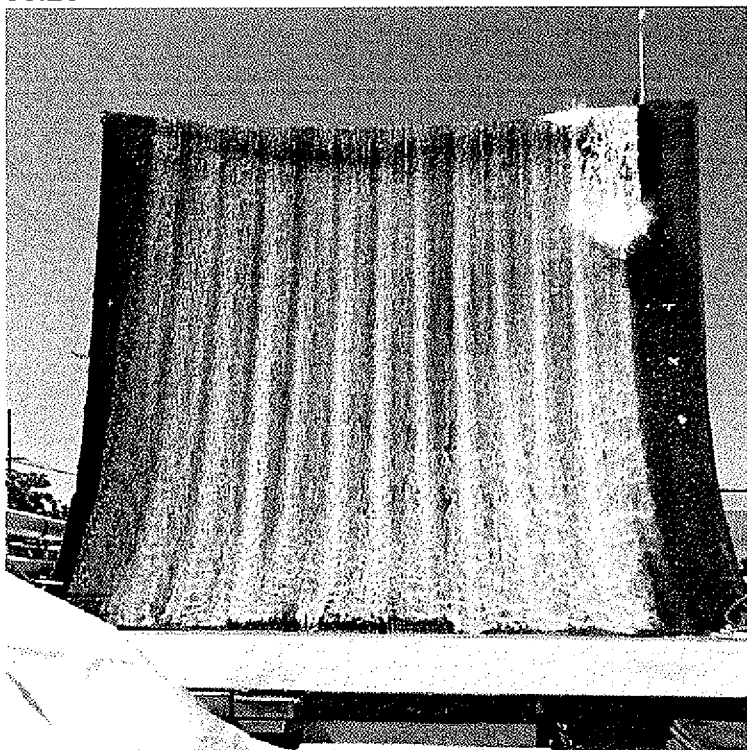


FIGURE 17G

00:27

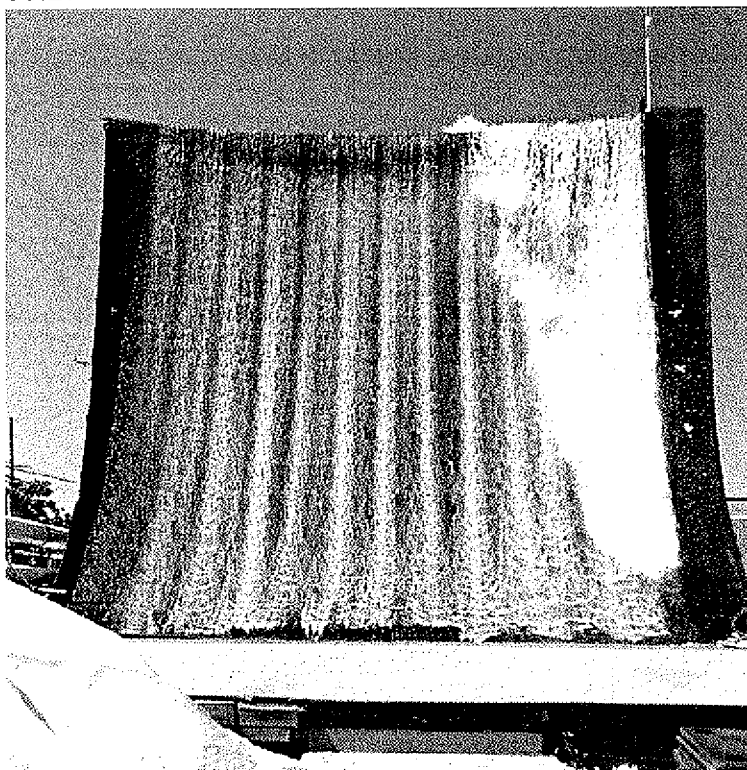


FIGURE 17H

00:29

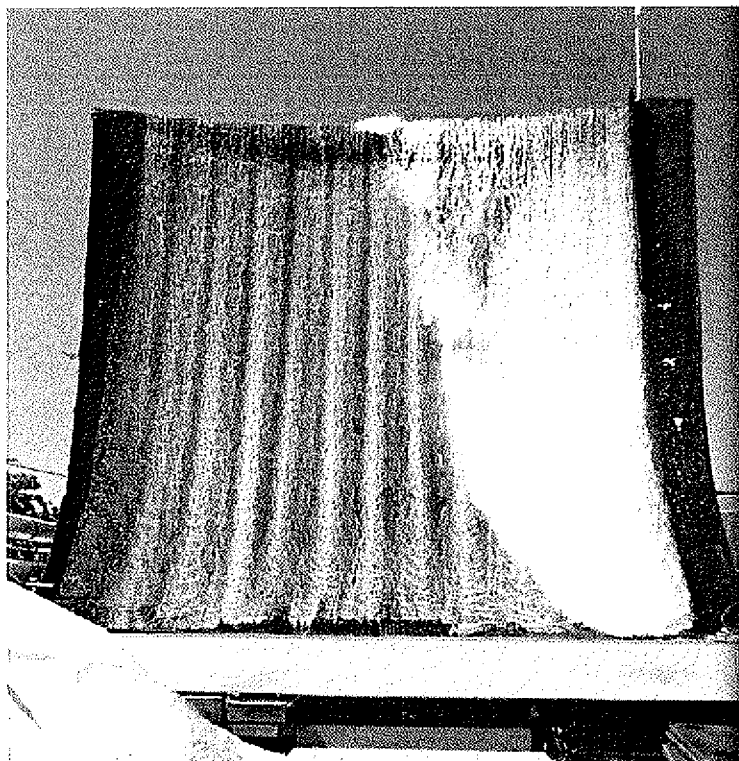


FIGURE 17I

00:30

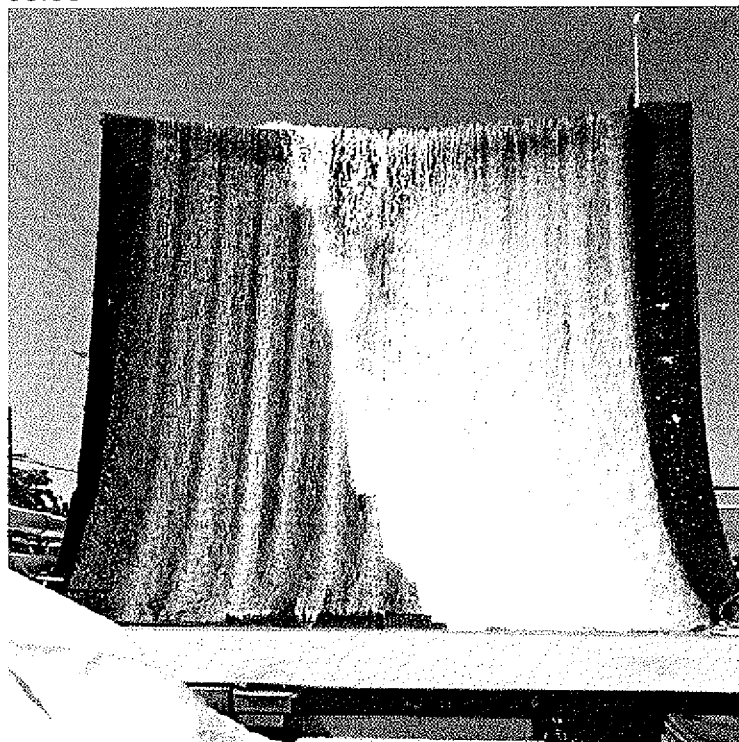


FIGURE 17J

00:33

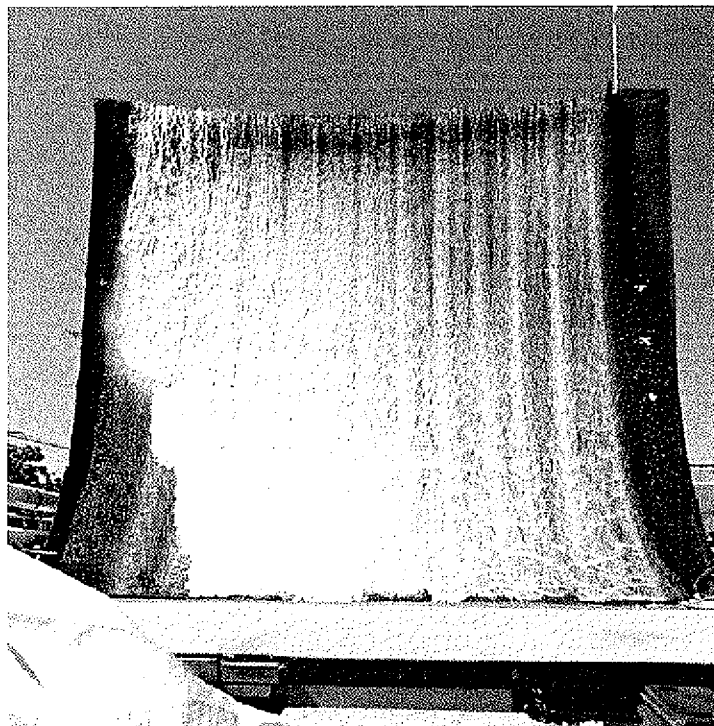


FIGURE 17K

00:35

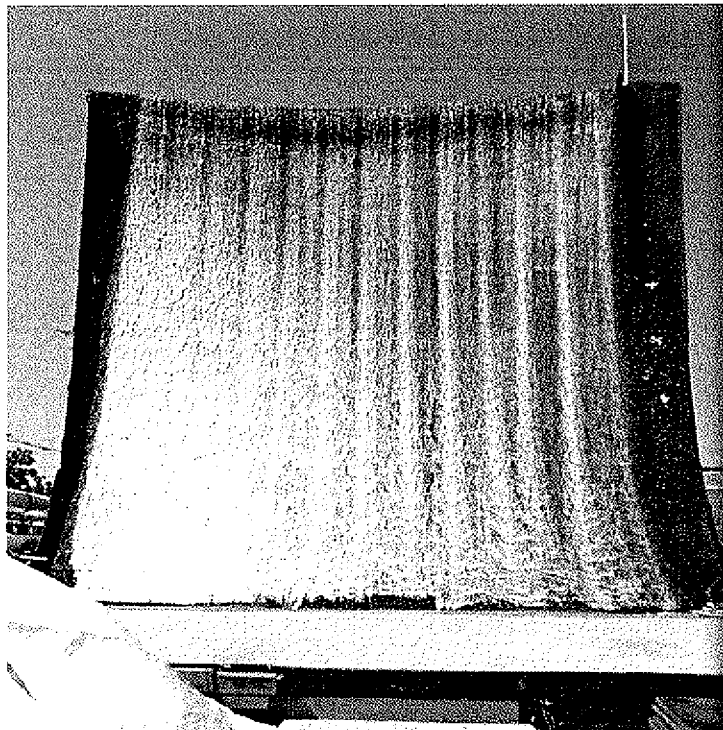


FIGURE 17L

00:37

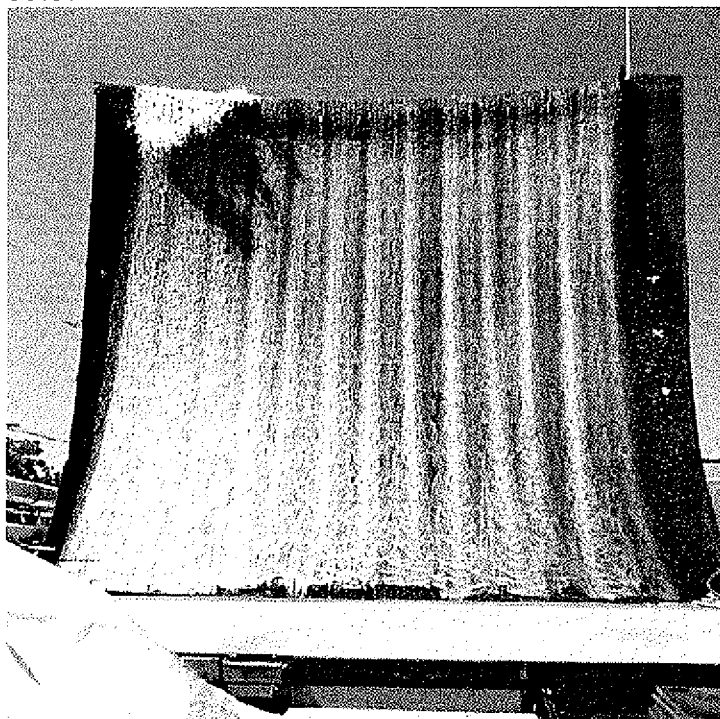


FIGURE 17M

00:38

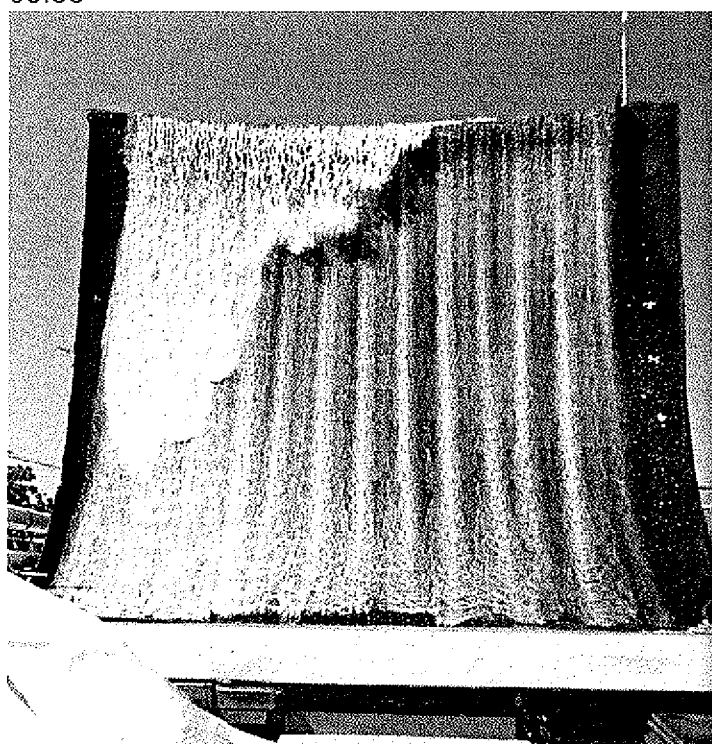


FIGURE 17N

00:38

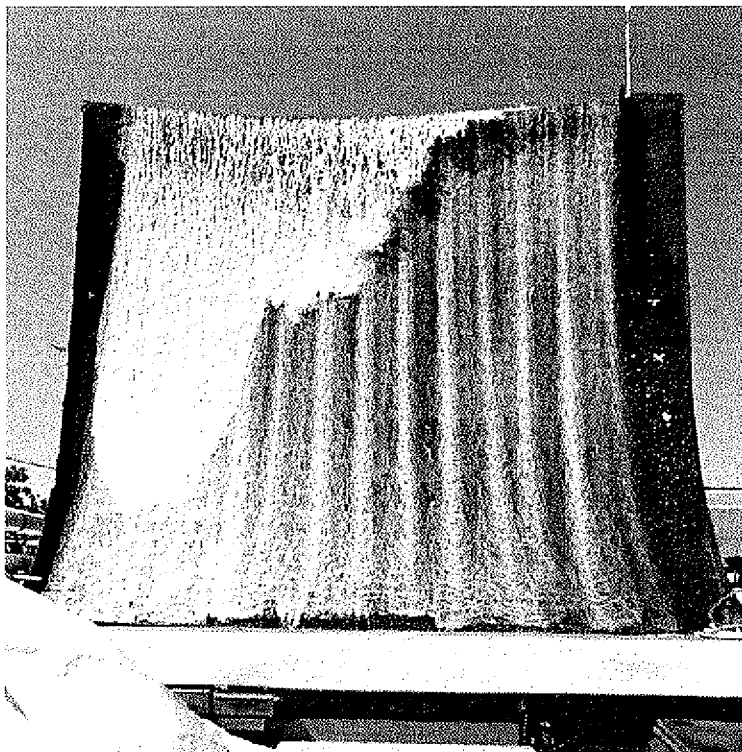


FIGURE 17O

00:42

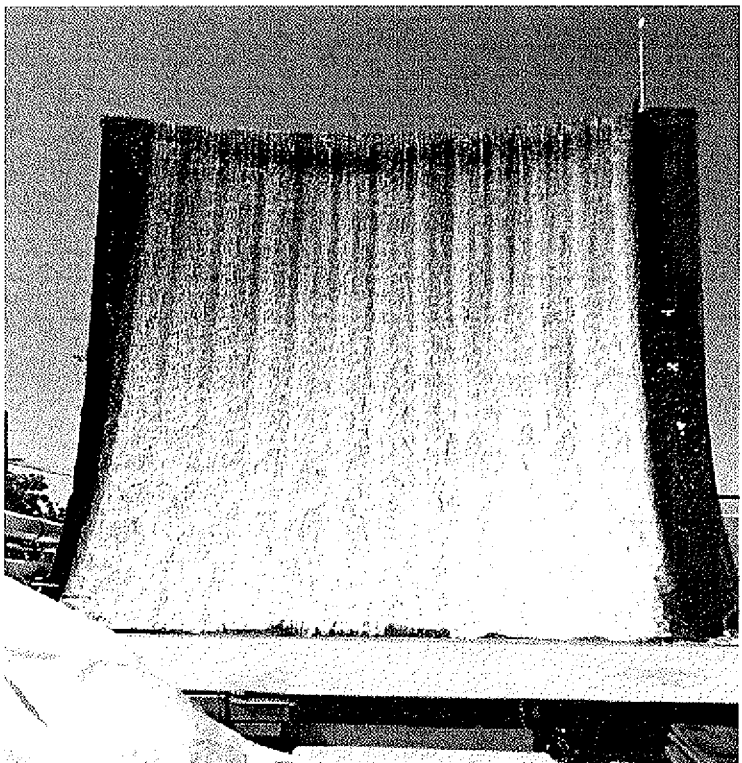


FIGURE 17P

00:42

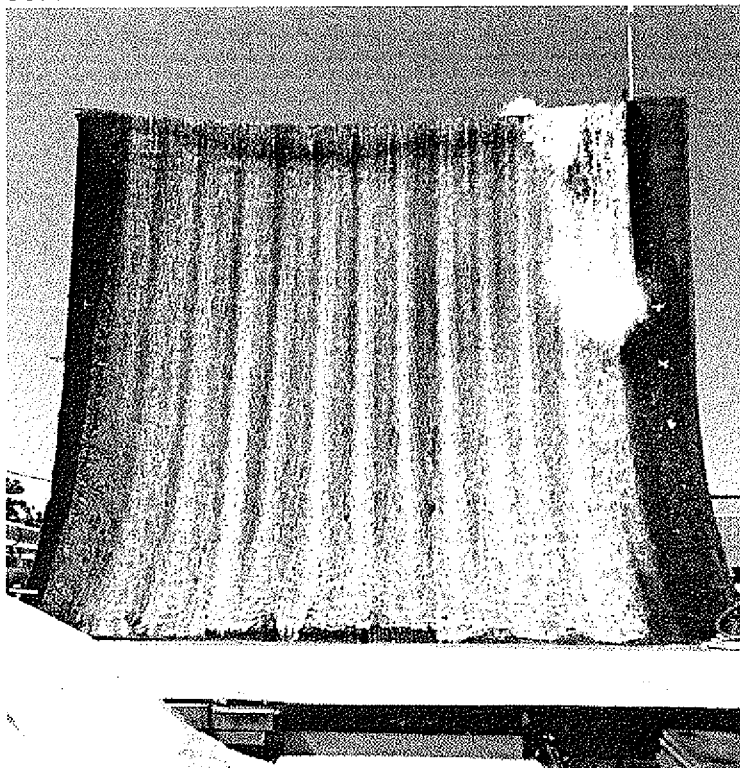


FIGURE 17Q

00:43

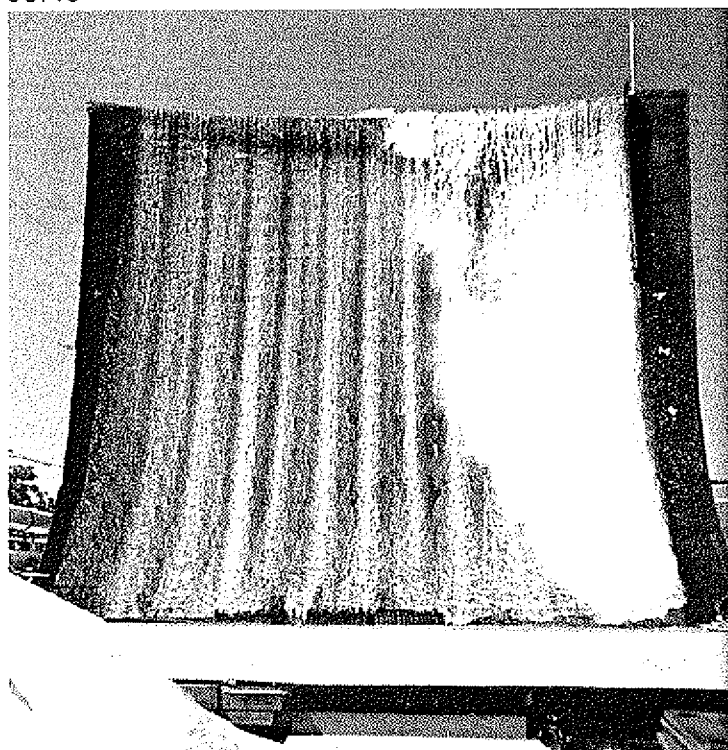


FIGURE 17R

00:44

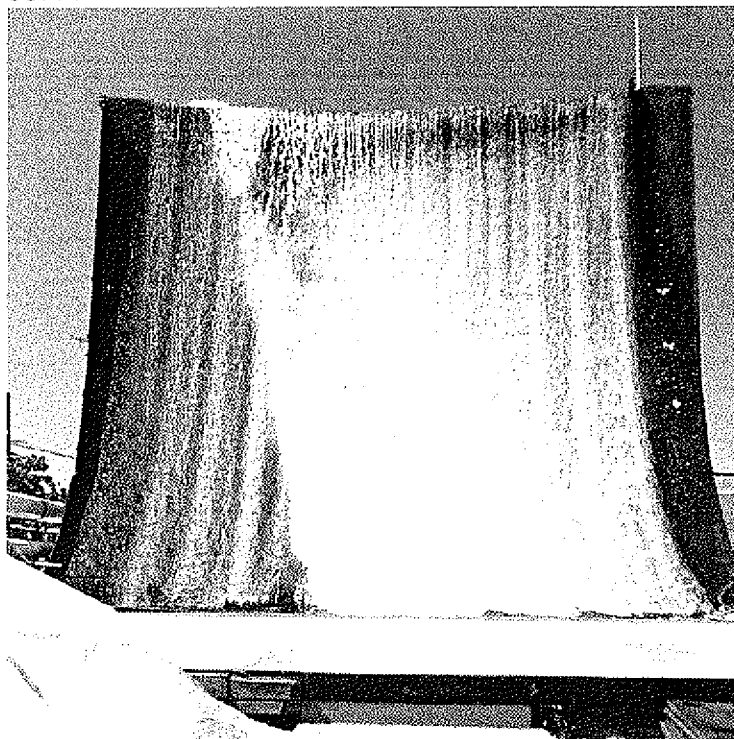


FIGURE 17S

00:50

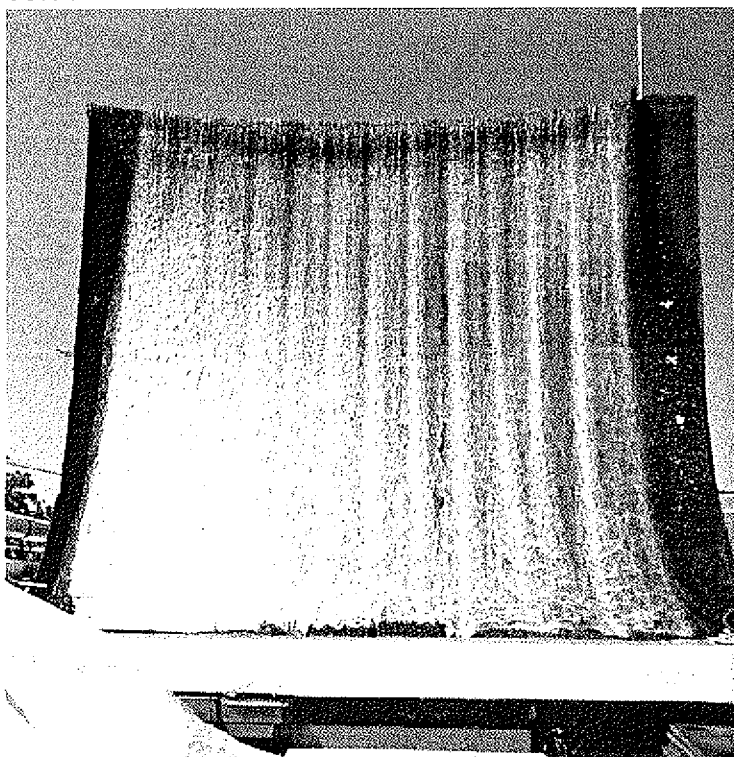


FIGURE 17T

01:07

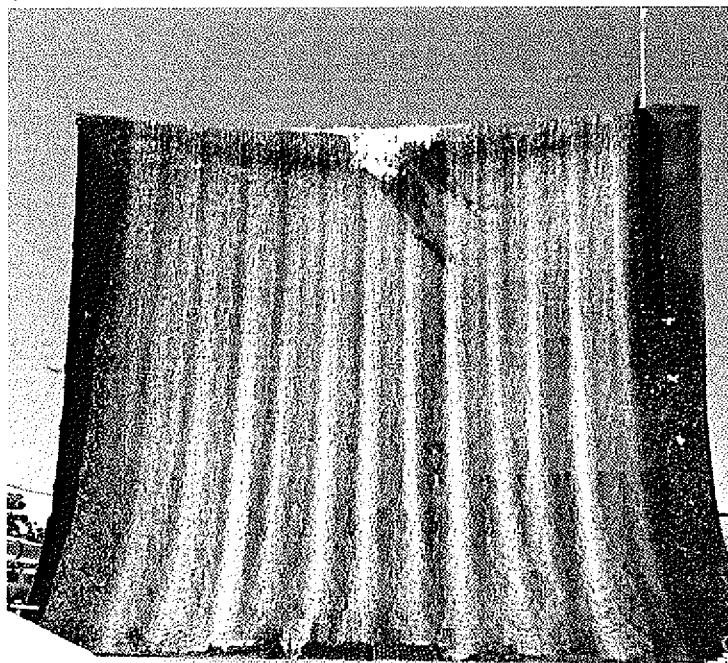


FIGURE 17U



01:07

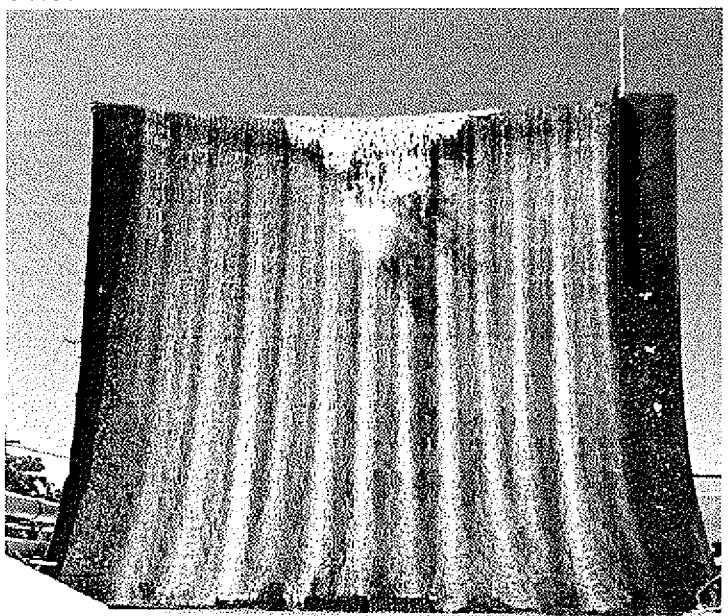


FIGURE 17V



01:08

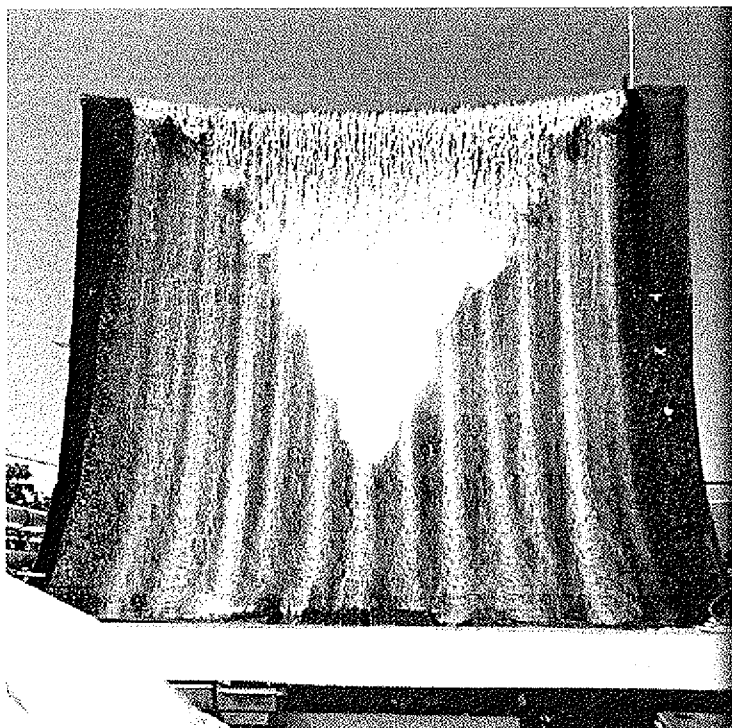


FIGURE 17W

01:09

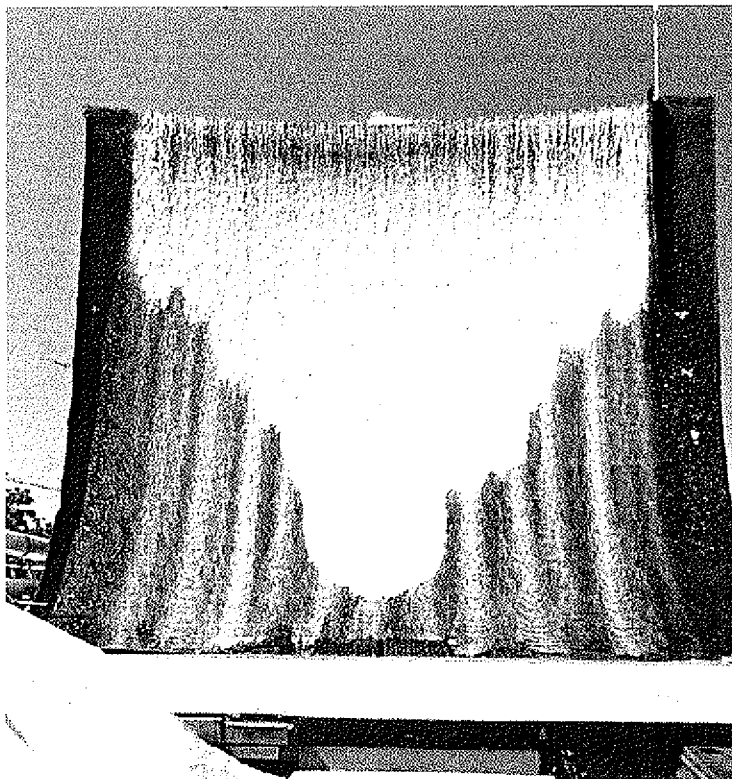


FIGURE 17X

01:10

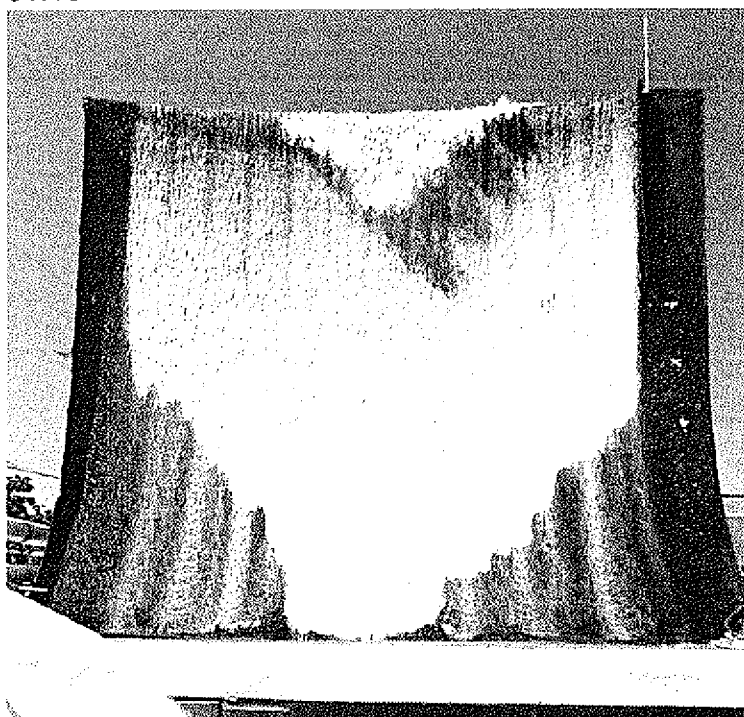


FIGURE 17Y

01:11

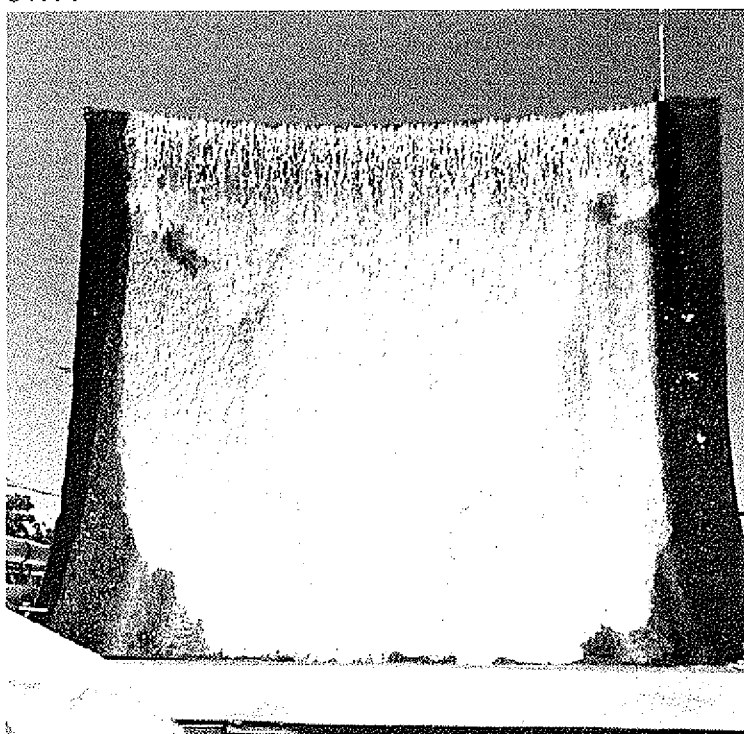


FIGURE 17Z

01:13

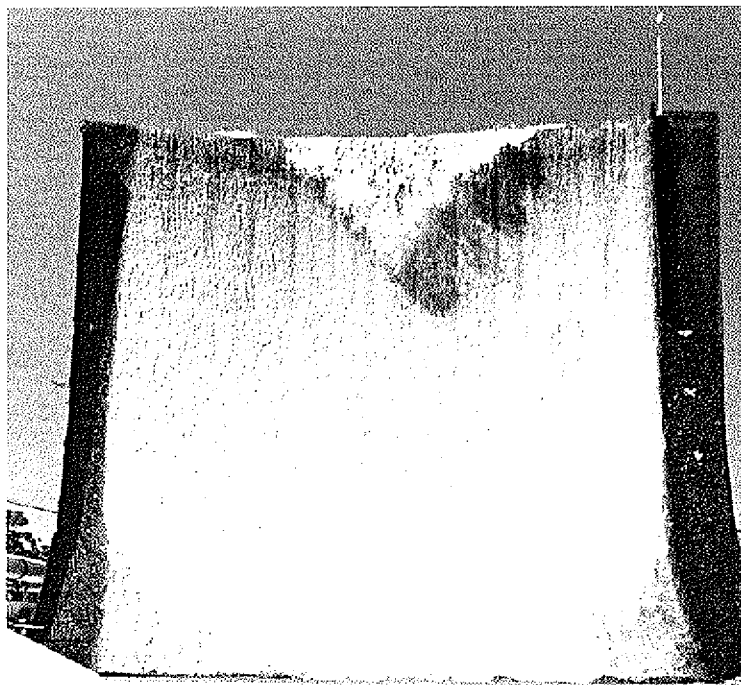


FIGURE 17AA

01:15

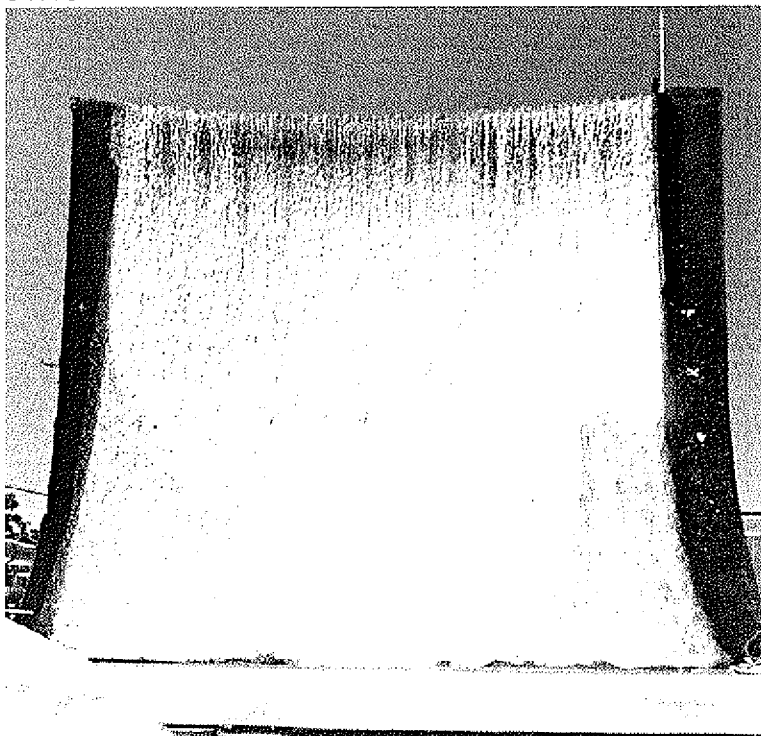


FIGURE 17BB

01:17

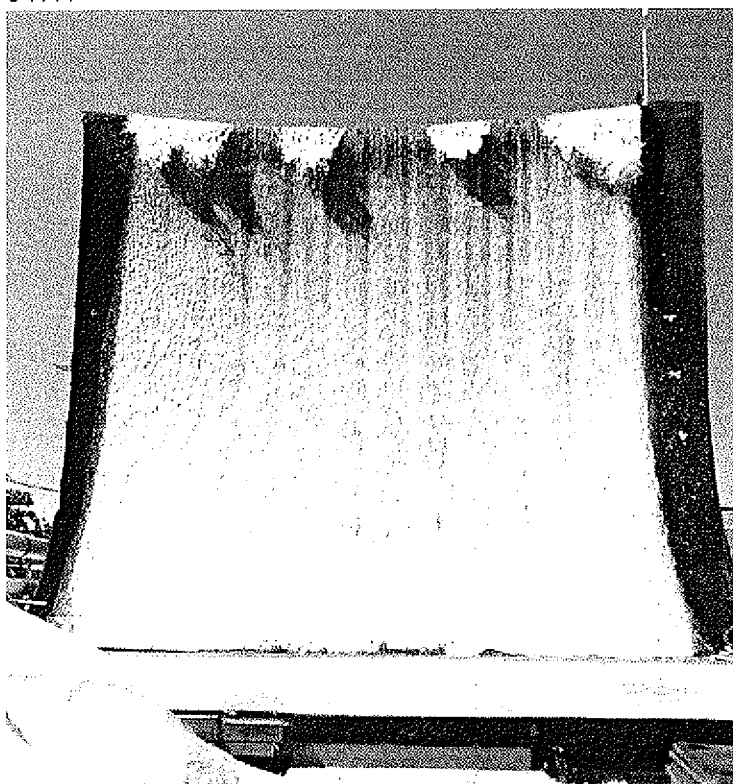


FIGURE 17CC

01:17

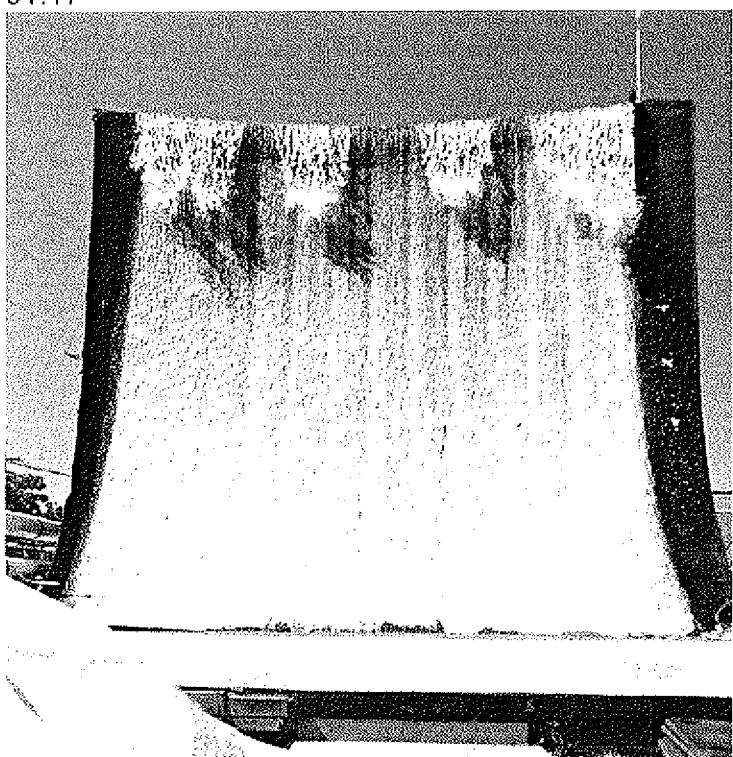


FIGURE 17DD

01:18

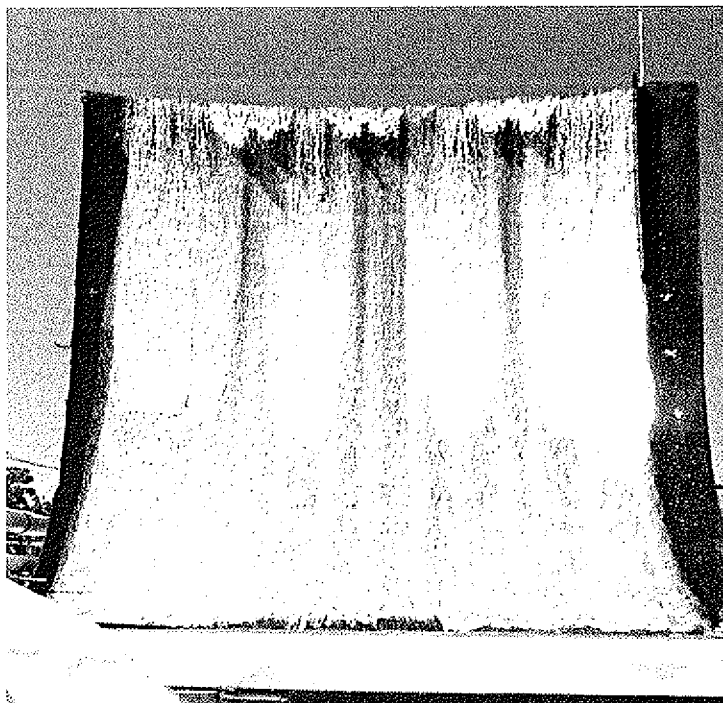


FIGURE 17EE

01:19

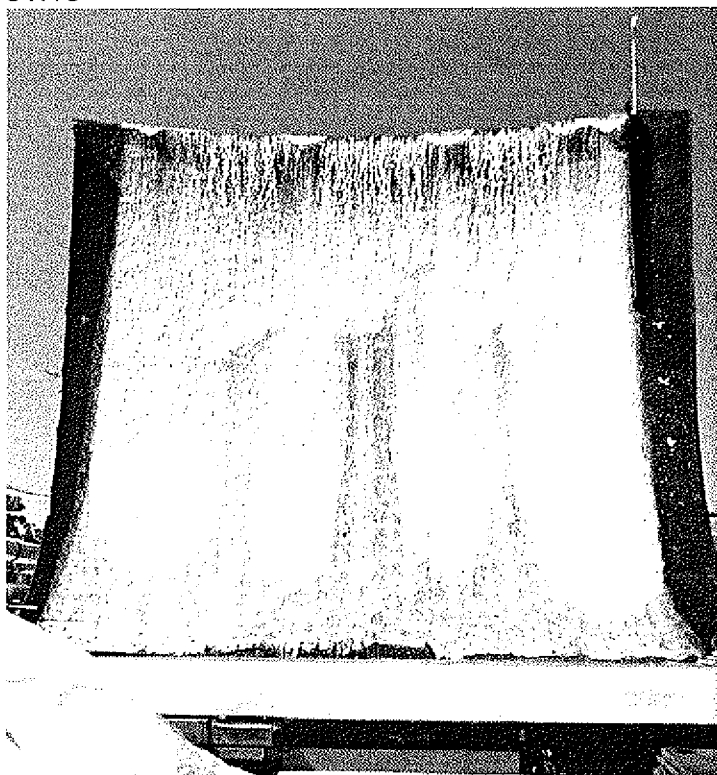


FIGURE 17FF

01:19

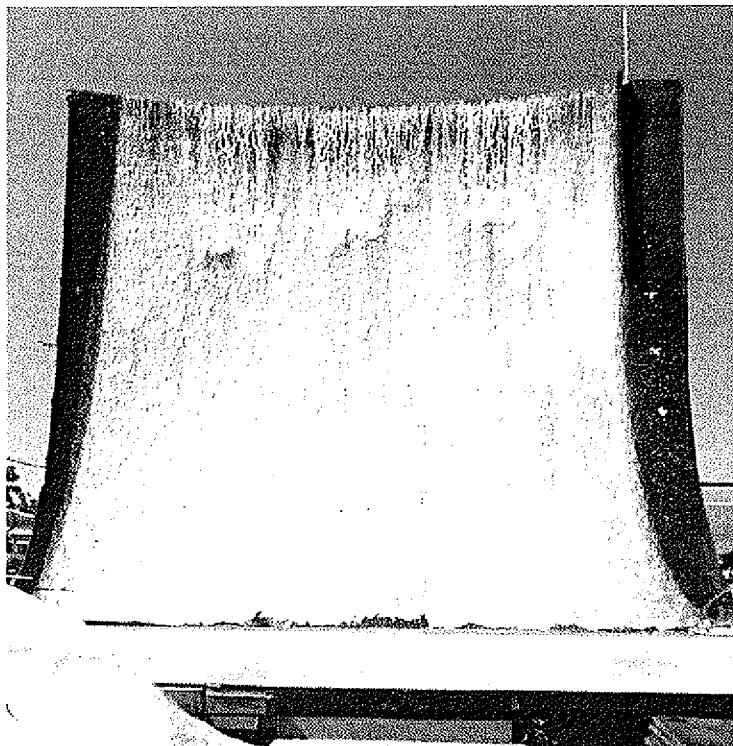


FIGURE 17GG

01:20

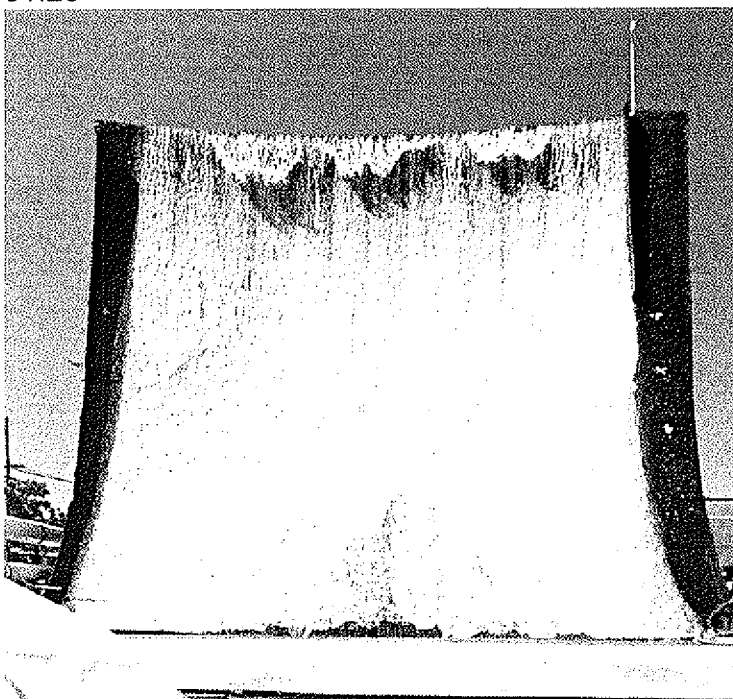


FIGURE 17HH

01:22

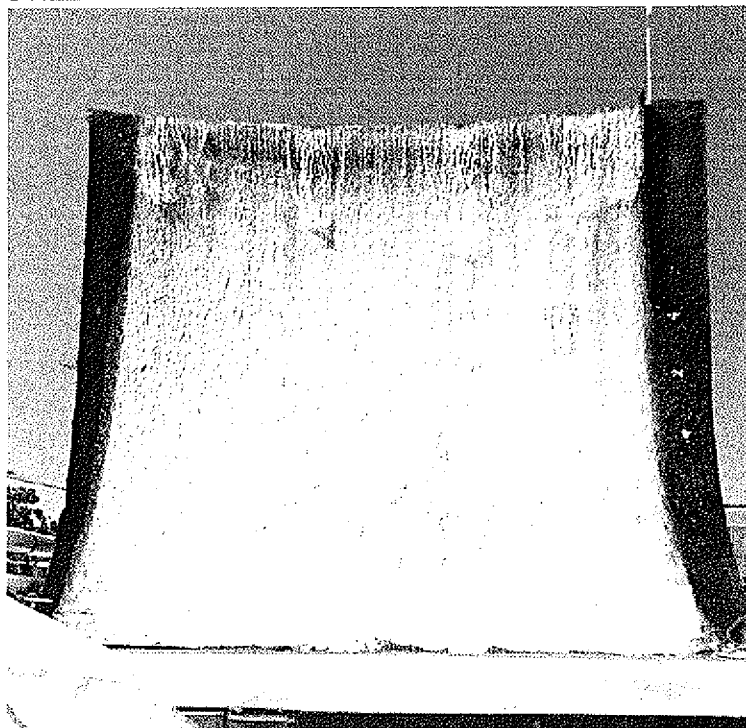


FIGURE 17II

01:24

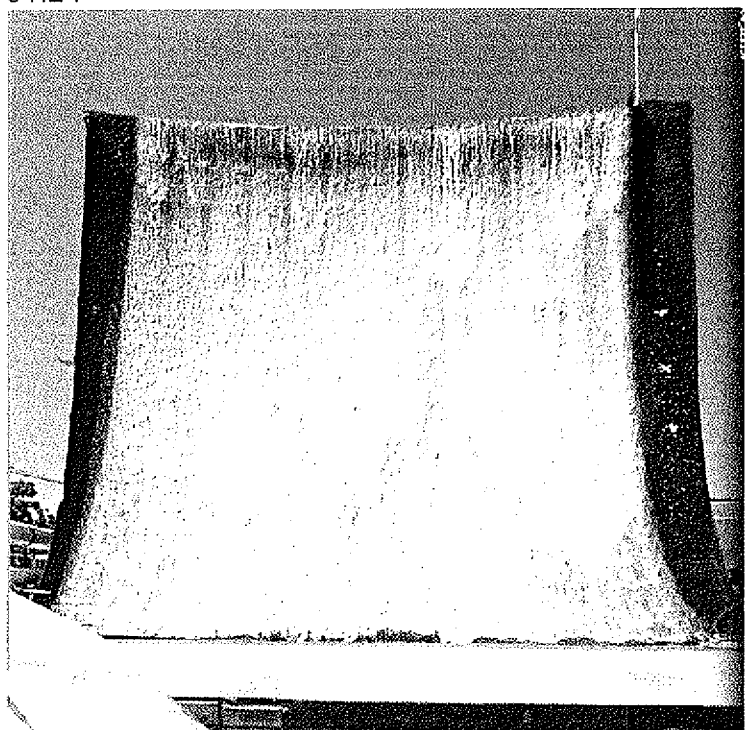


FIGURE 17JJ

01:26

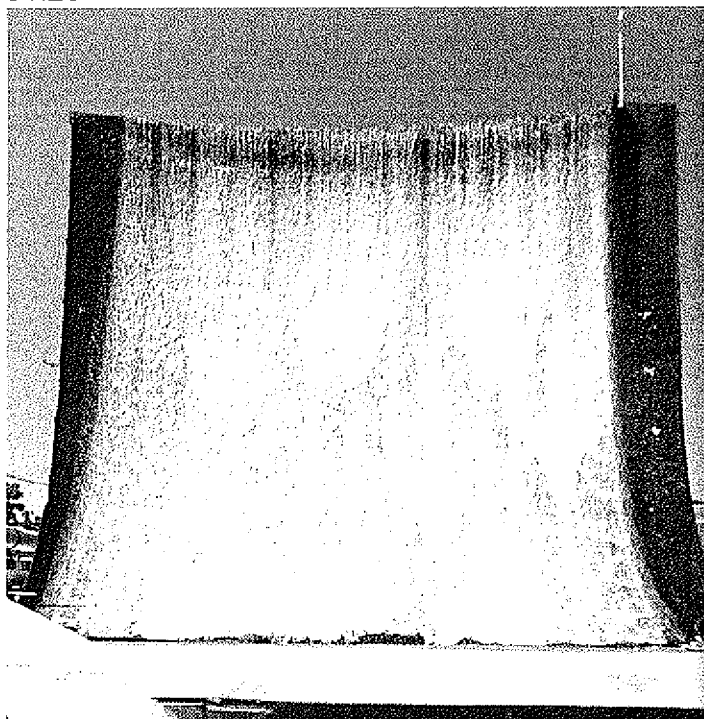


FIGURE 17KK

01:28

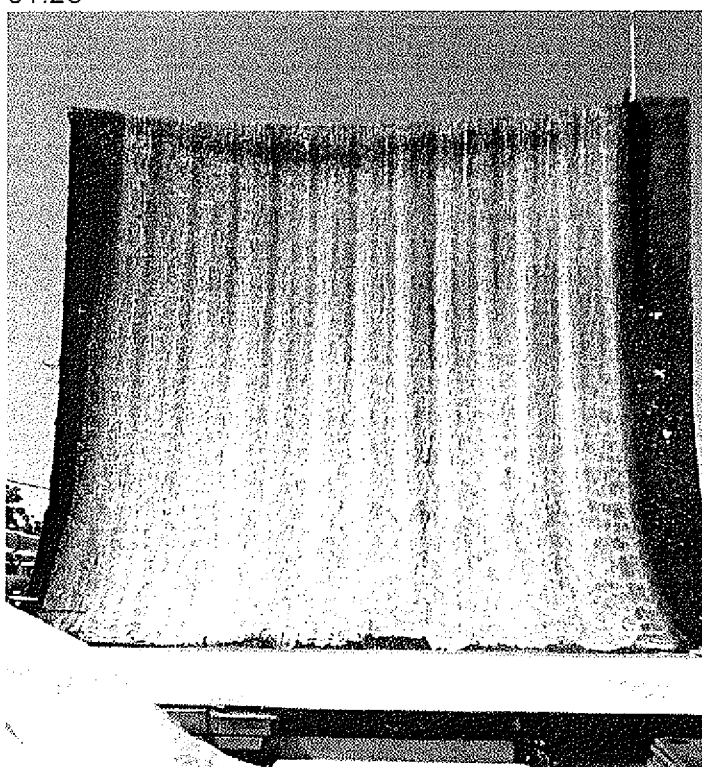


FIGURE 17LL

01:30

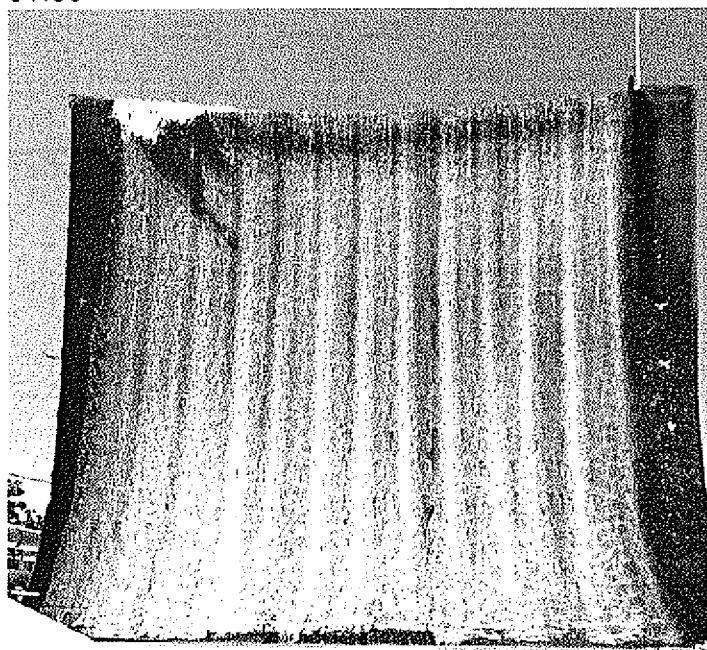


FIGURE 17MM

01:32

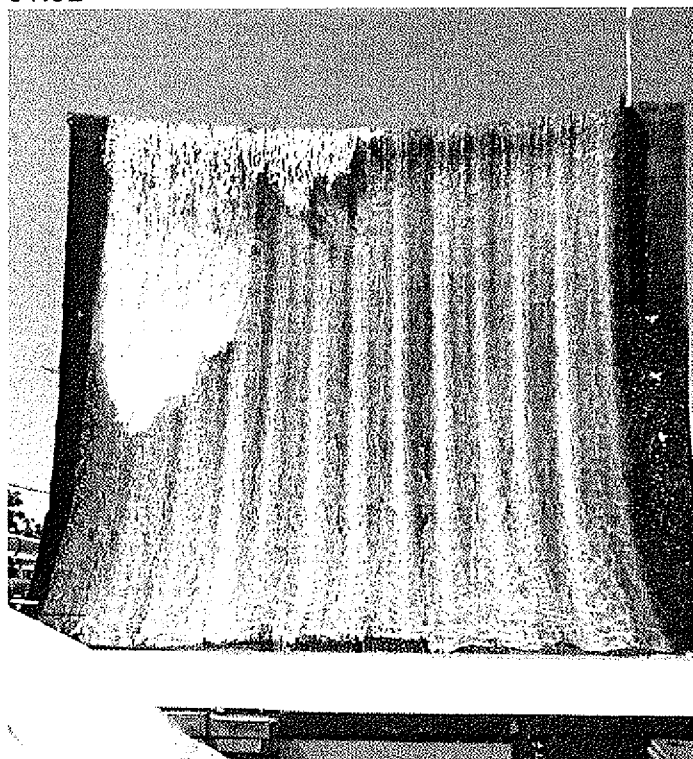


FIGURE 17NN

01:33

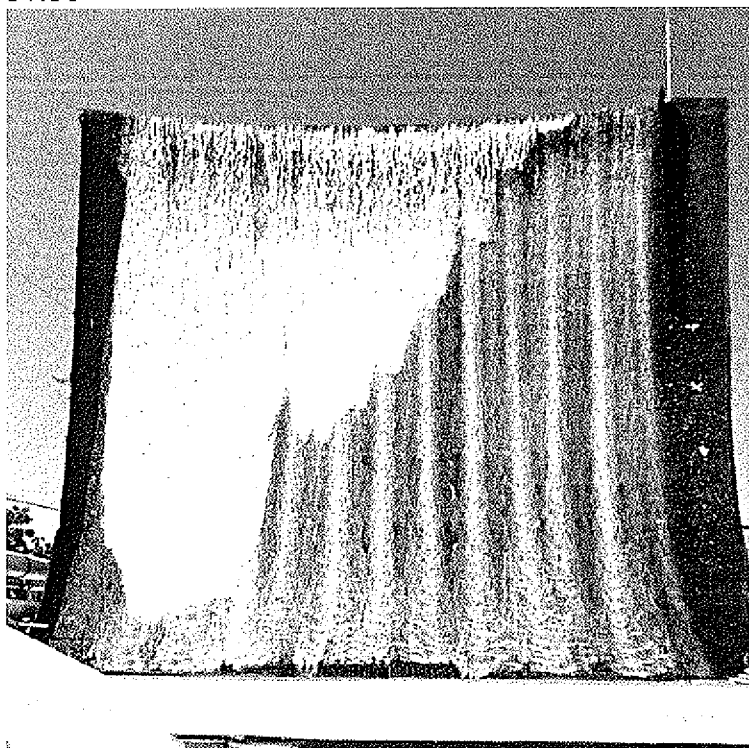


FIGURE 1700

01:35

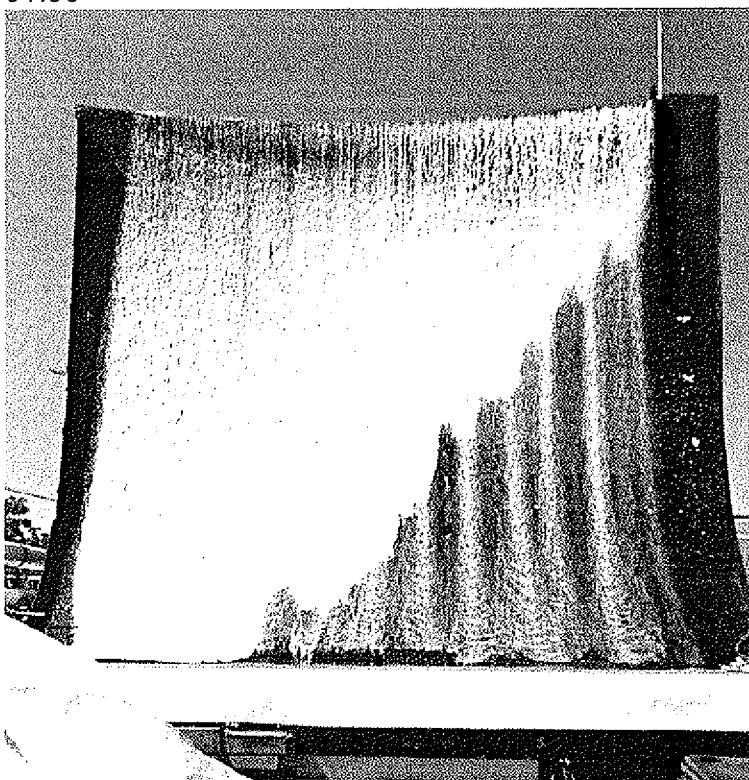


FIGURE 17PP

01:35

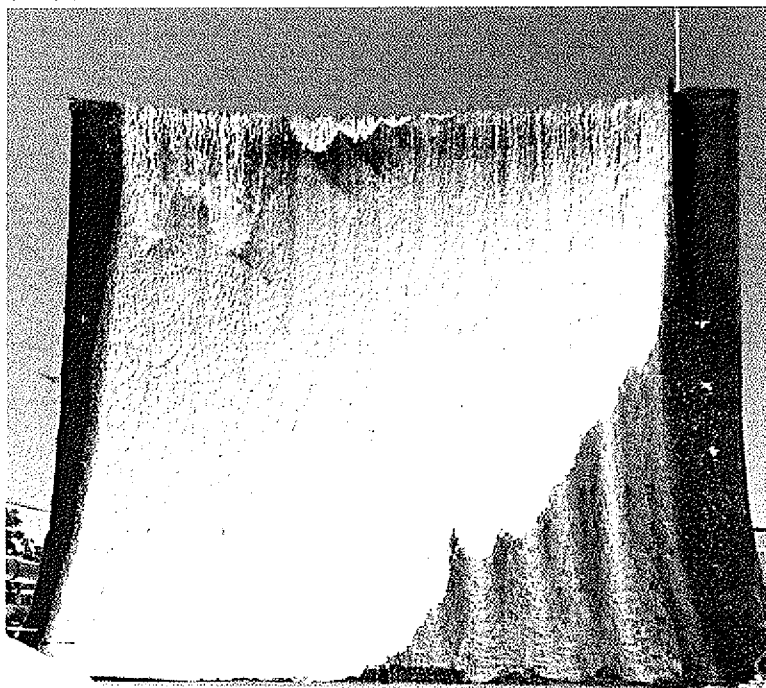


FIGURE 17QQ

01:37

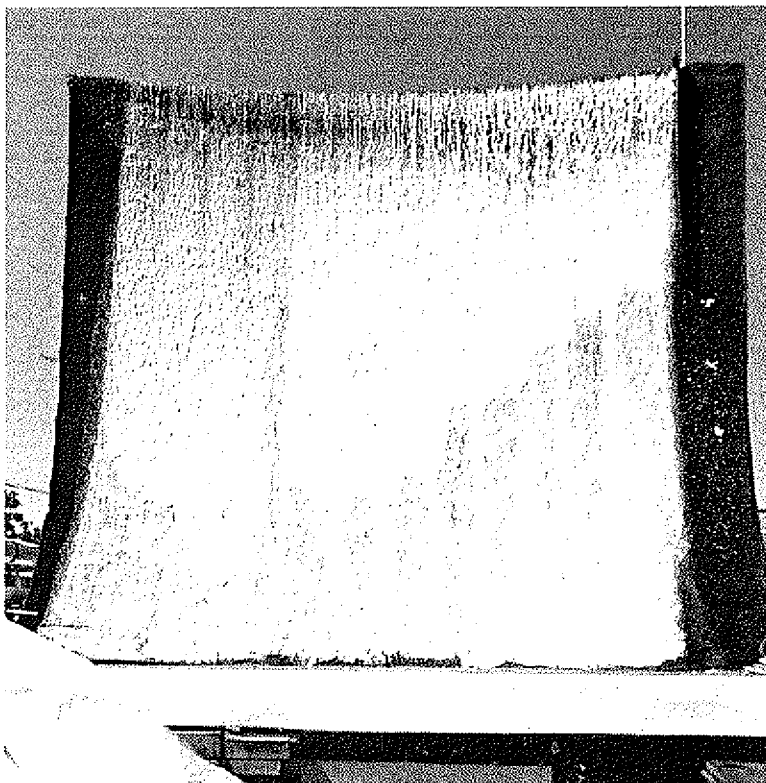


FIGURE 17RR

01:38

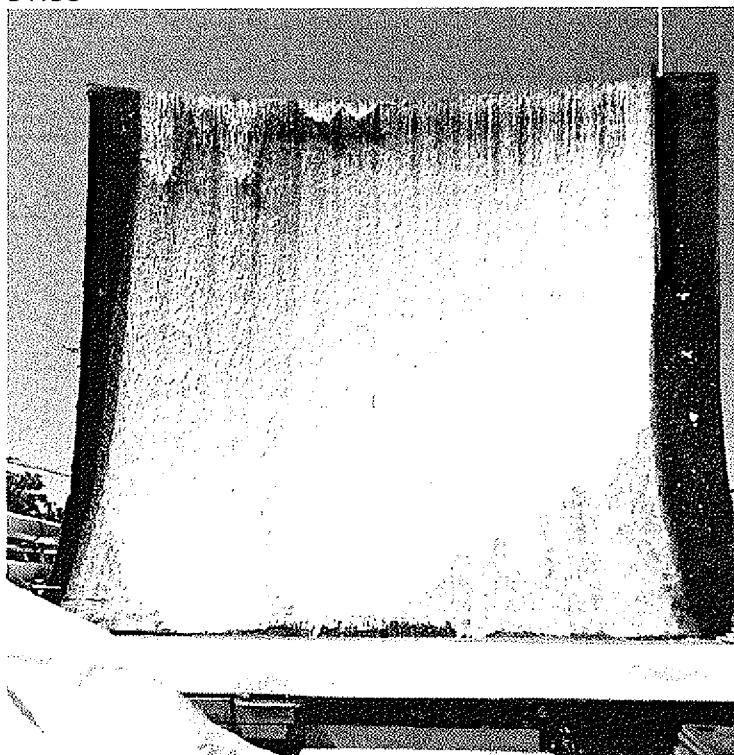


FIGURE 17SS

01:39

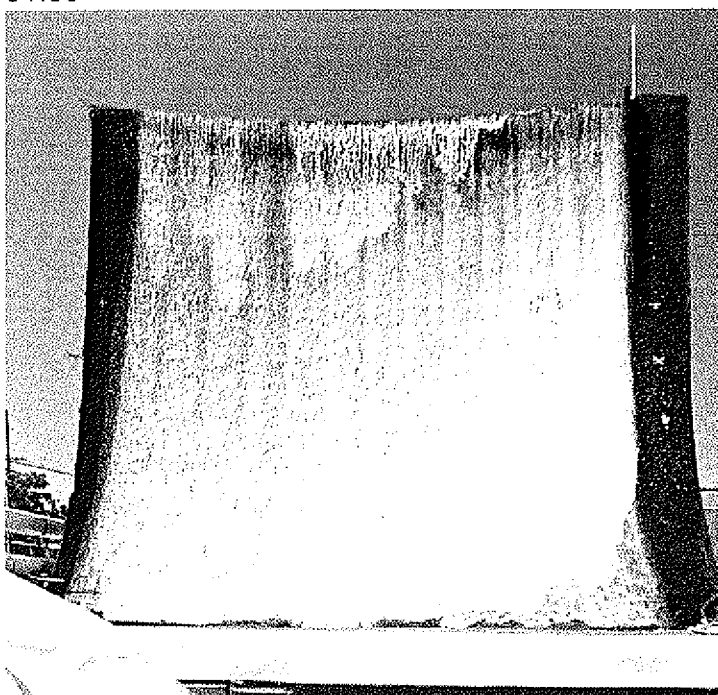


FIGURE 17TT

01:40

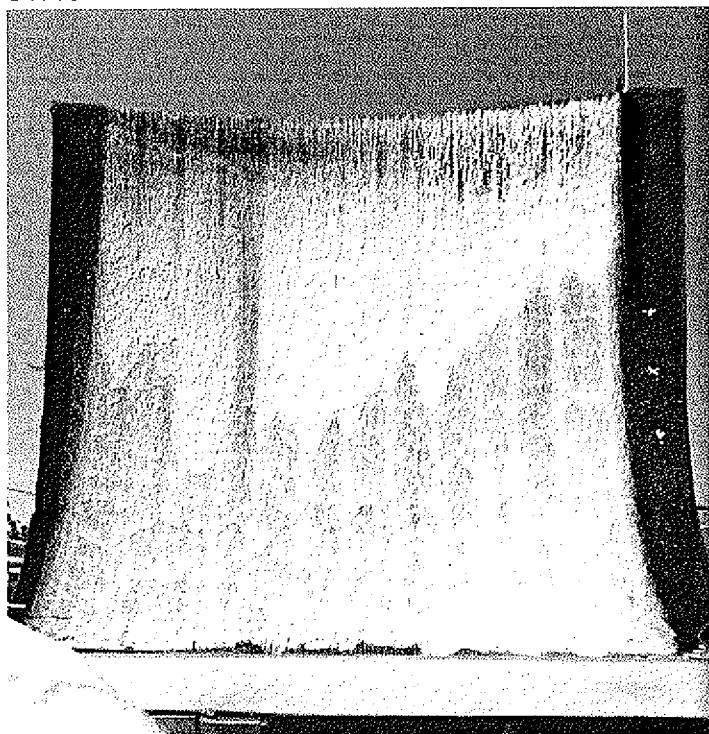


FIGURE 17UU

01:41

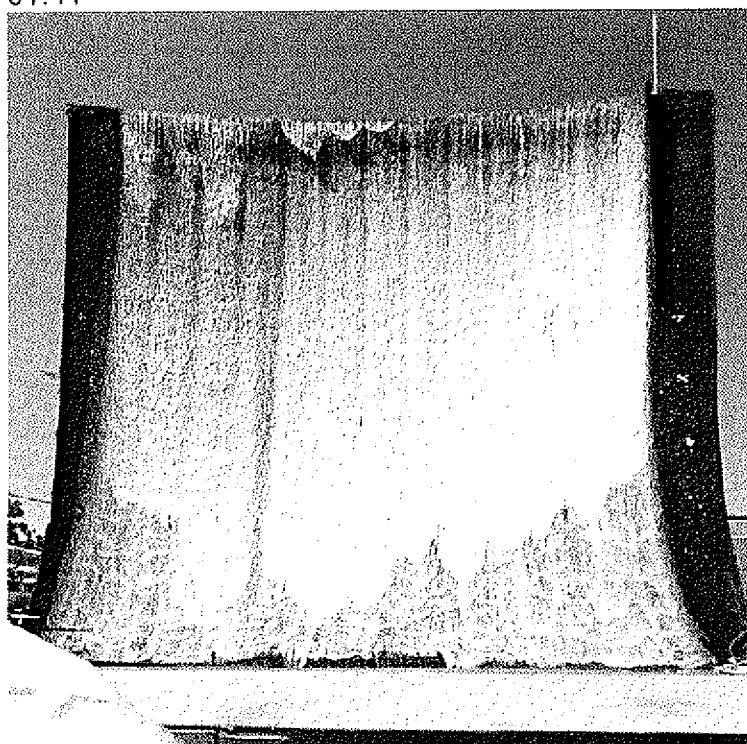


FIGURE 17VV

01:44

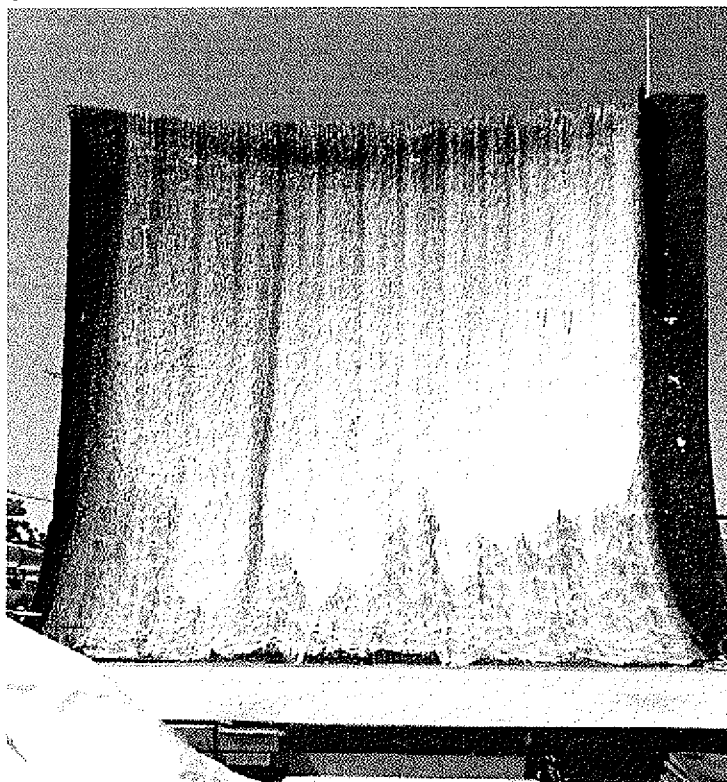


FIGURE 17WW

01:47

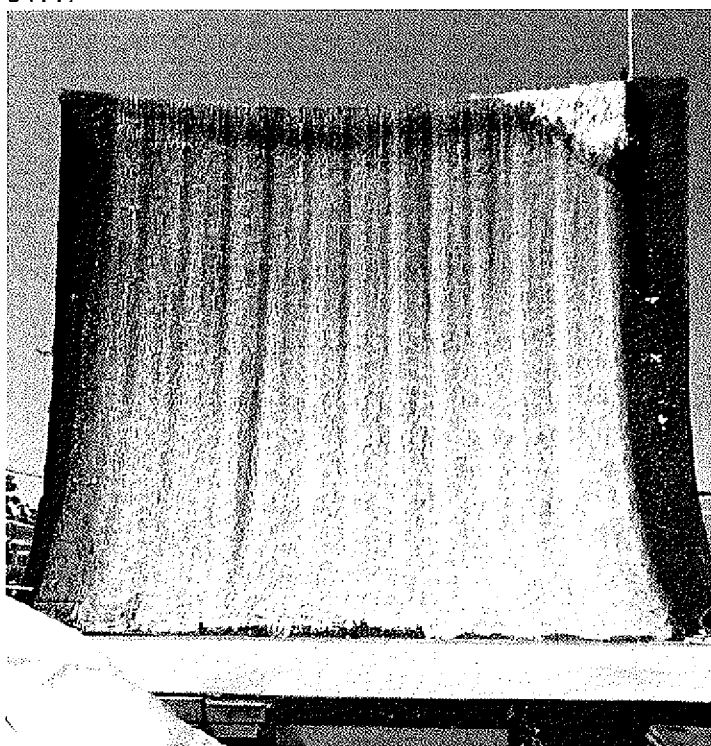


FIGURE 17XX

01:48

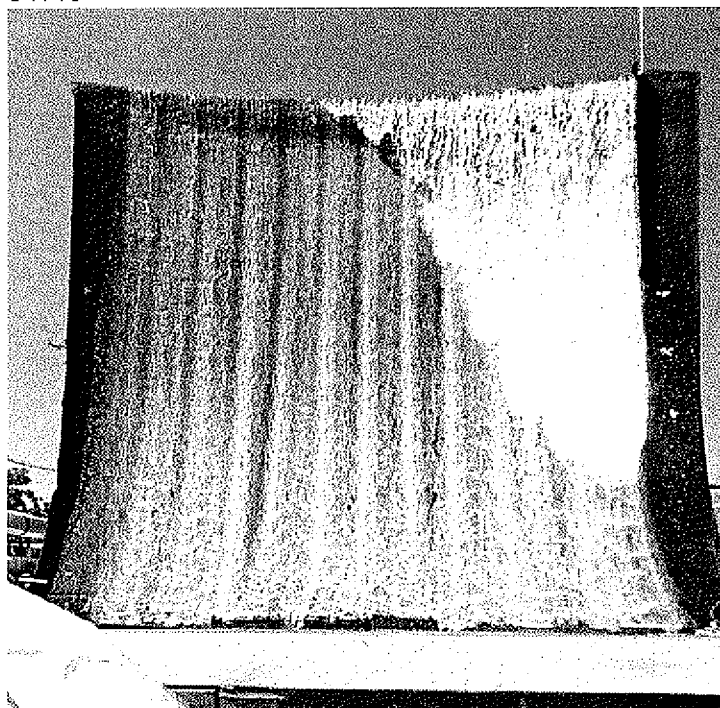


FIGURE 17YY

01:51

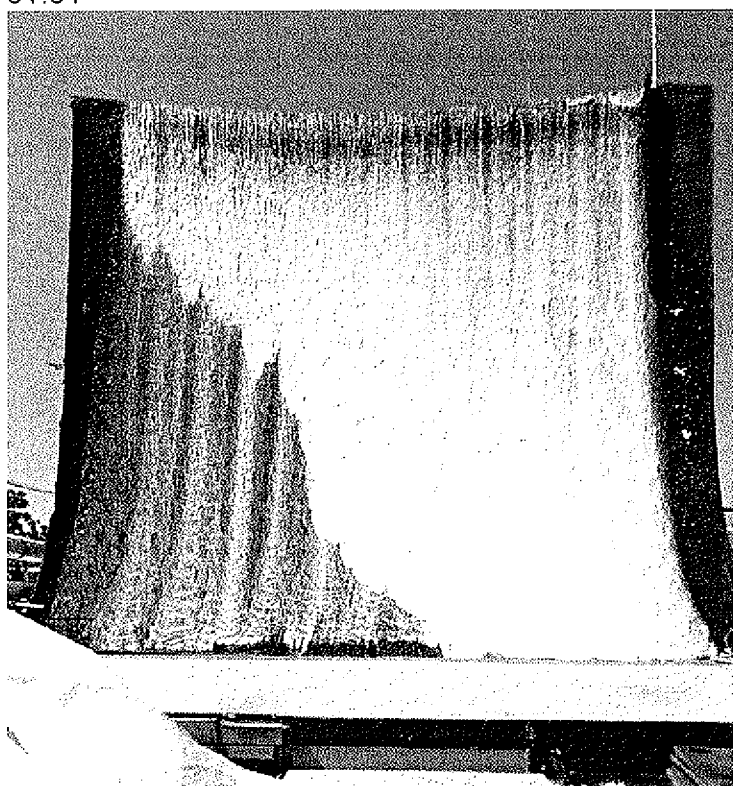


FIGURE 17ZZ

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01:52

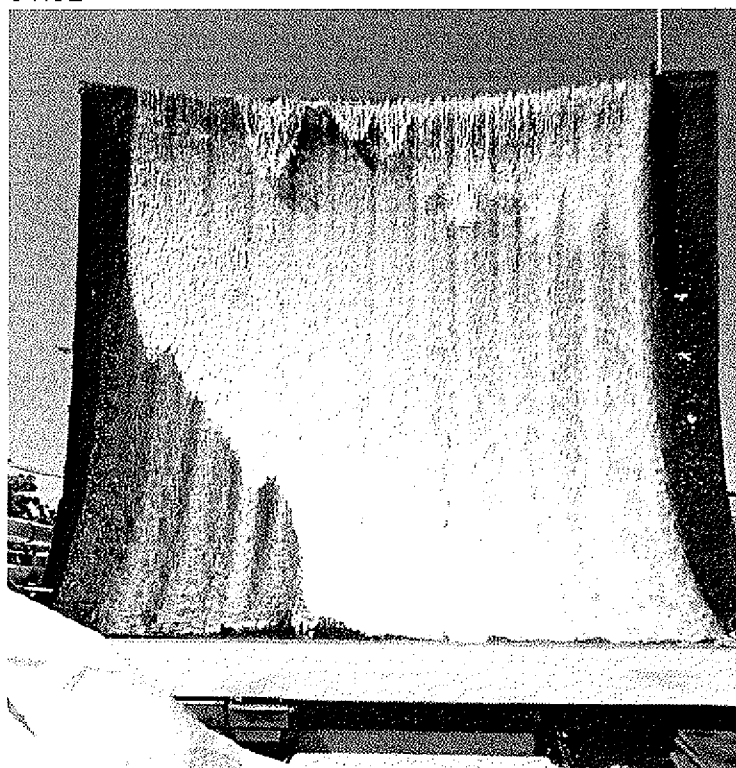


FIGURE 17AAA

01:53

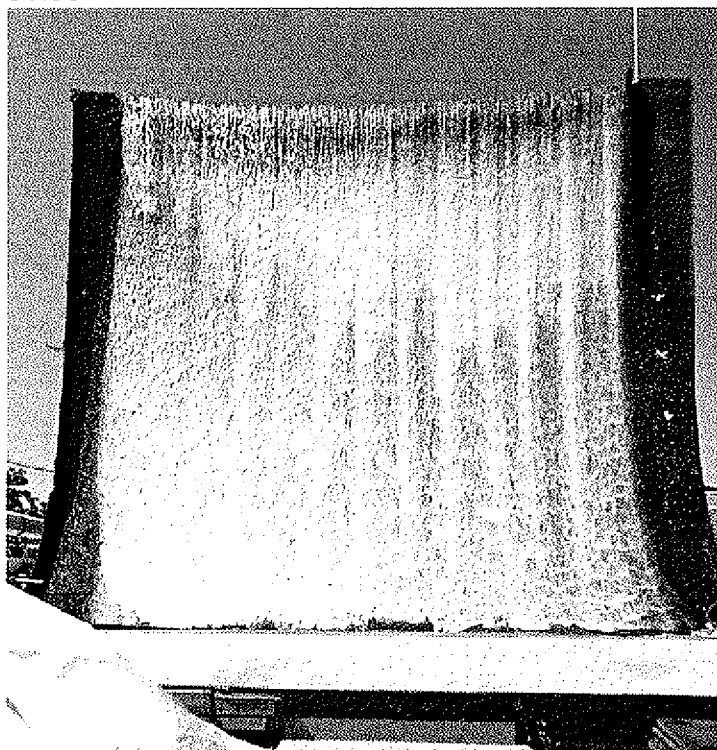


FIGURE 17BBB

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01:55

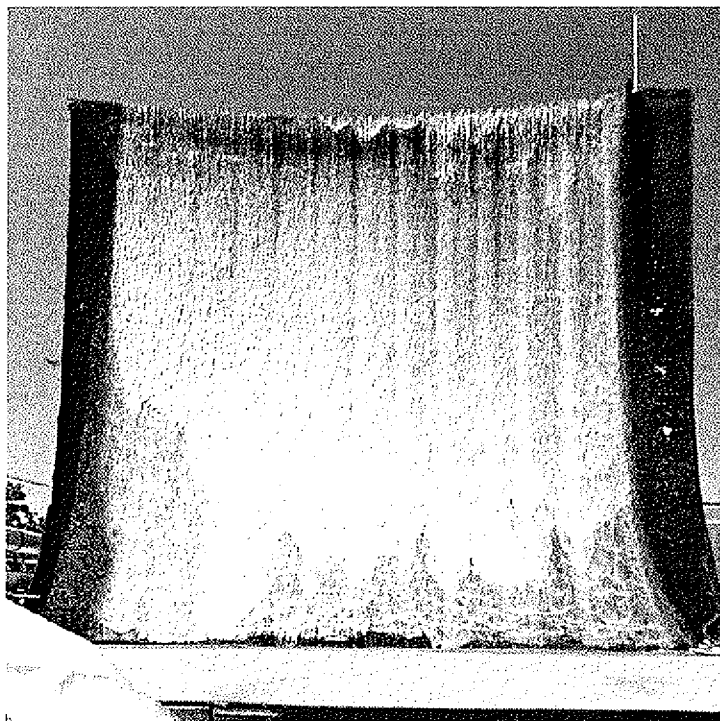


FIGURE 17CCC

01:56

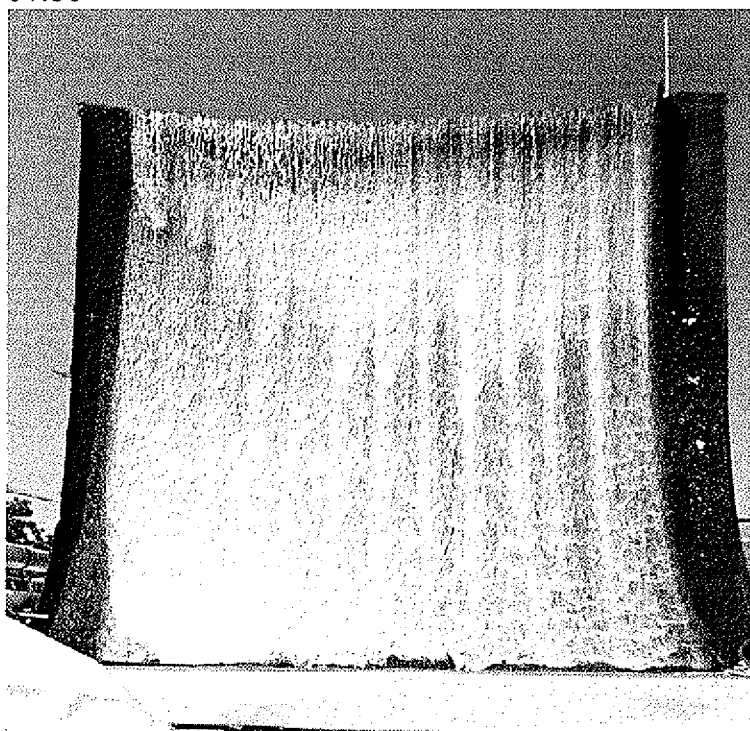


FIGURE 17DDD

01:58

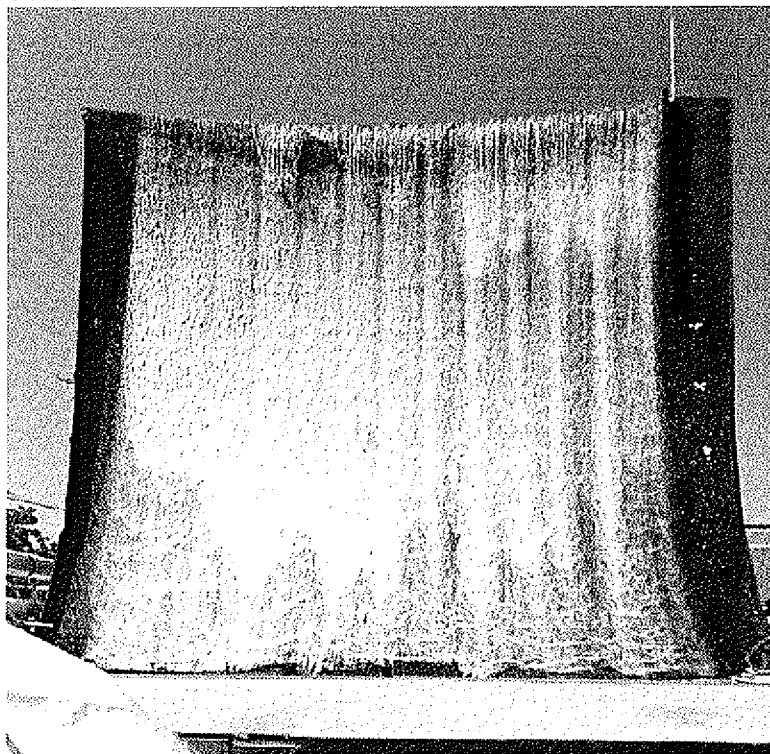


FIGURE 17EEE

02:00

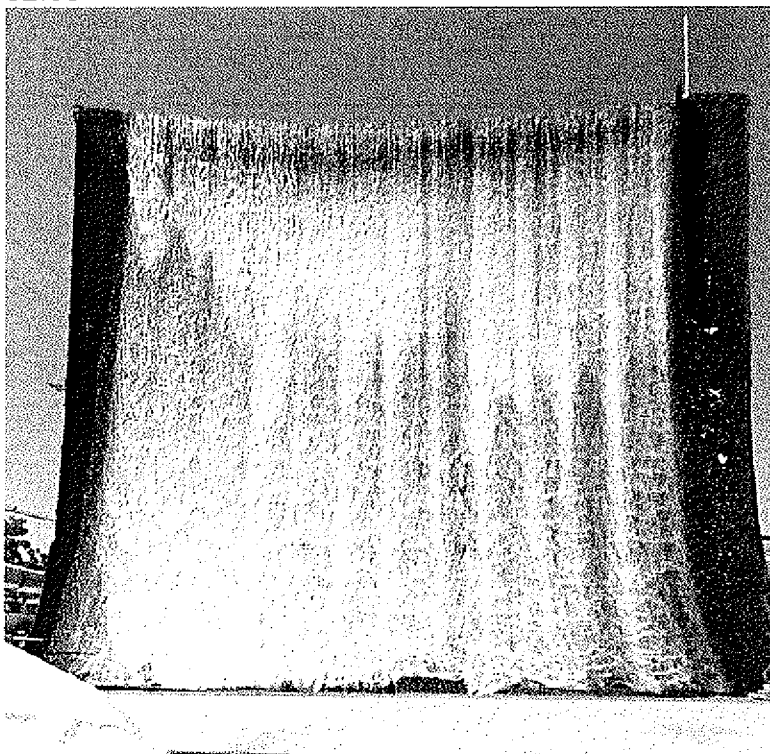


FIGURE 17FFF

02:02

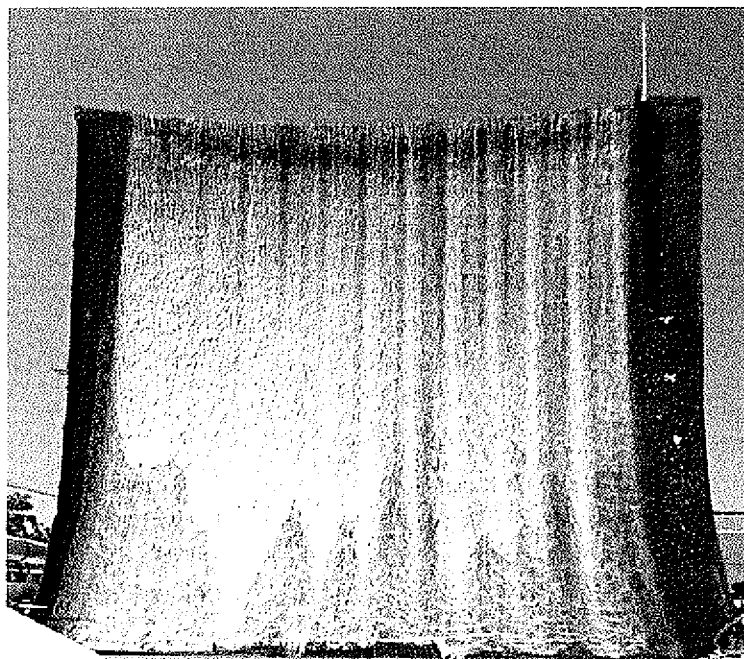


FIGURE 17GGG

02:04

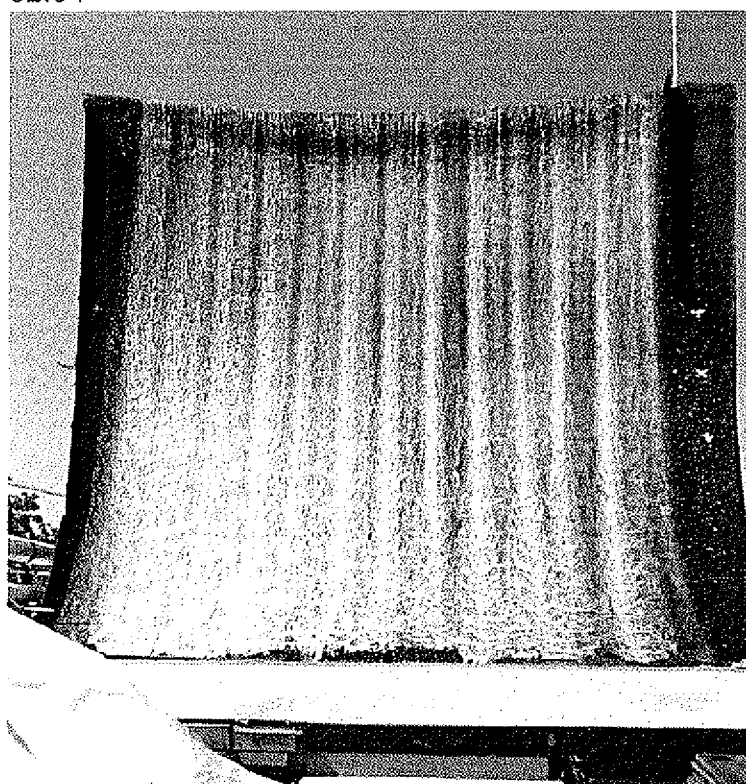


FIGURE 17HHH

02:10

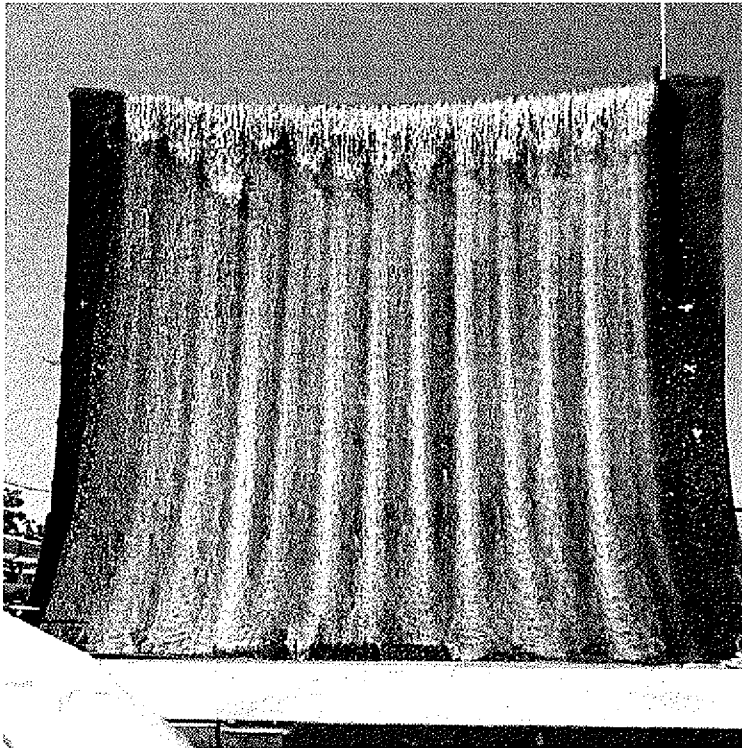


FIGURE 17III

02:11

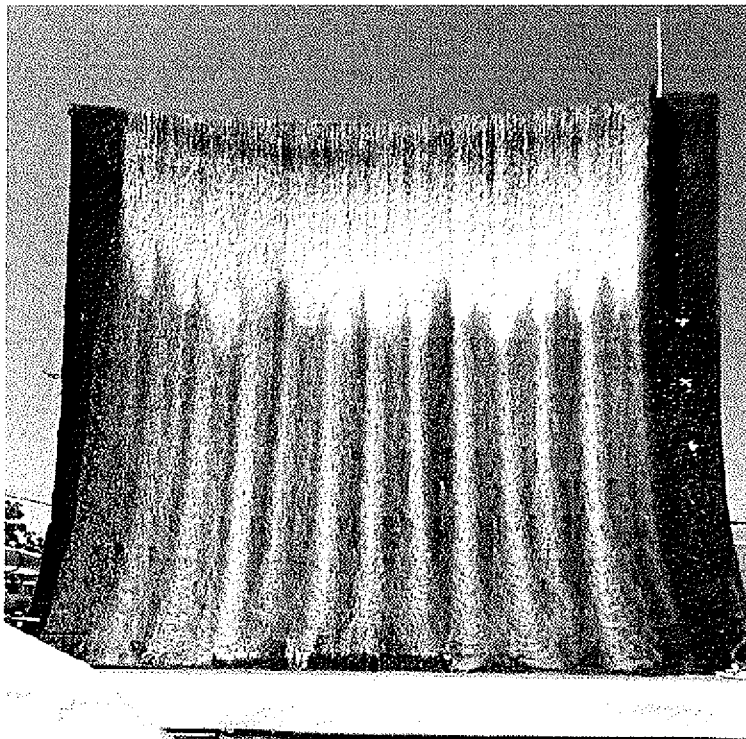


FIGURE 17JJJ

02:13

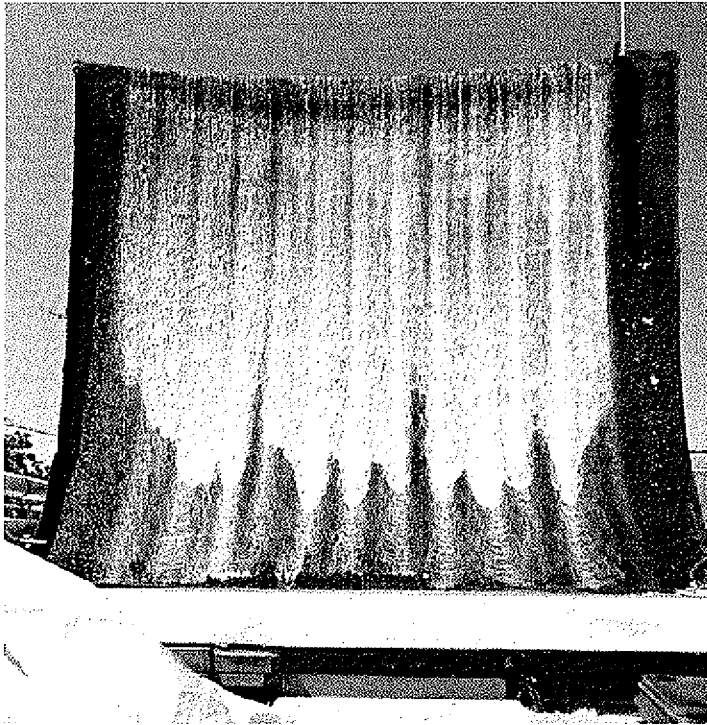


FIGURE 17KKK

02:14

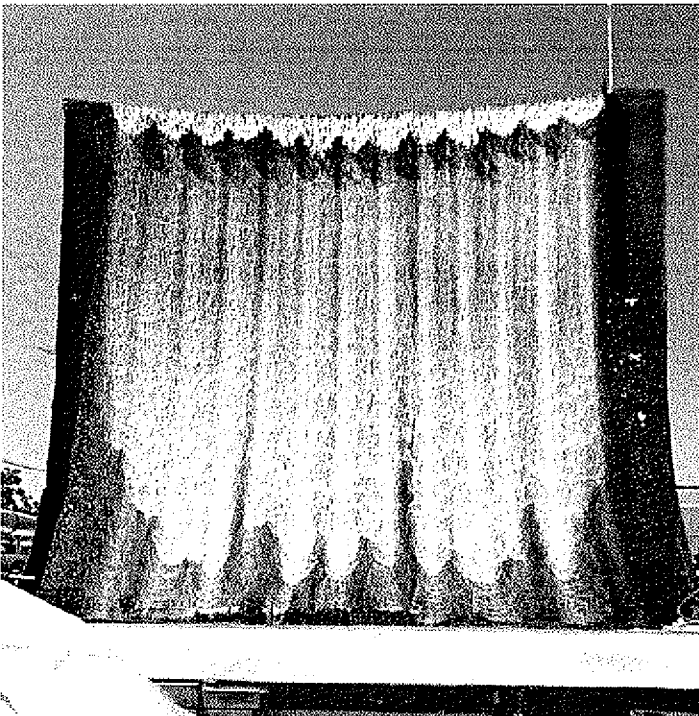


FIGURE 17LLL

02:15

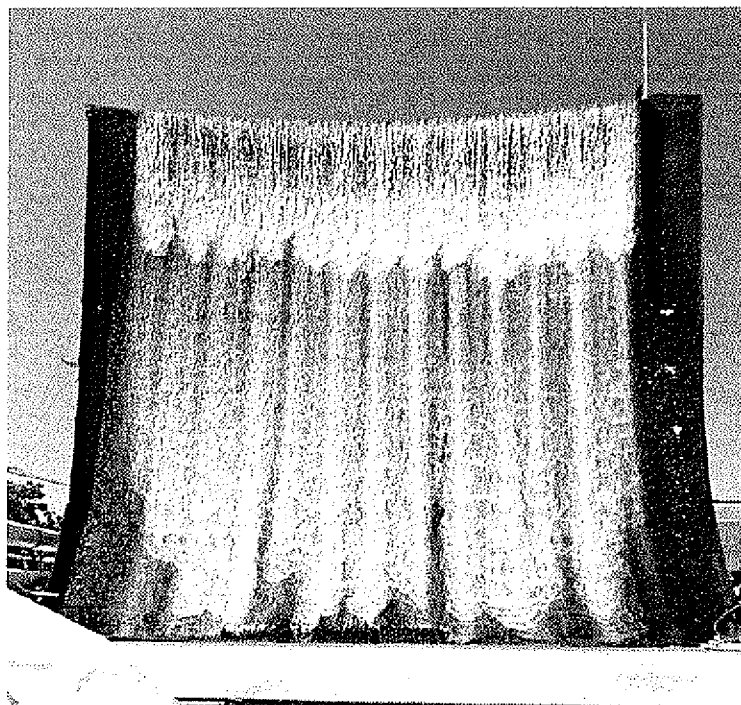


FIGURE 17MMM

02:17

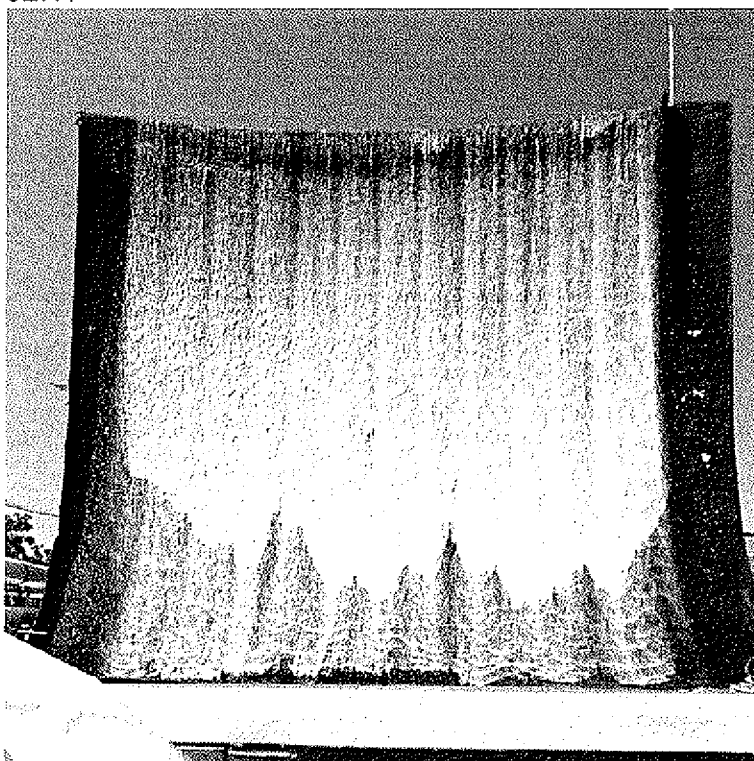


FIGURE 17NNN

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02:19

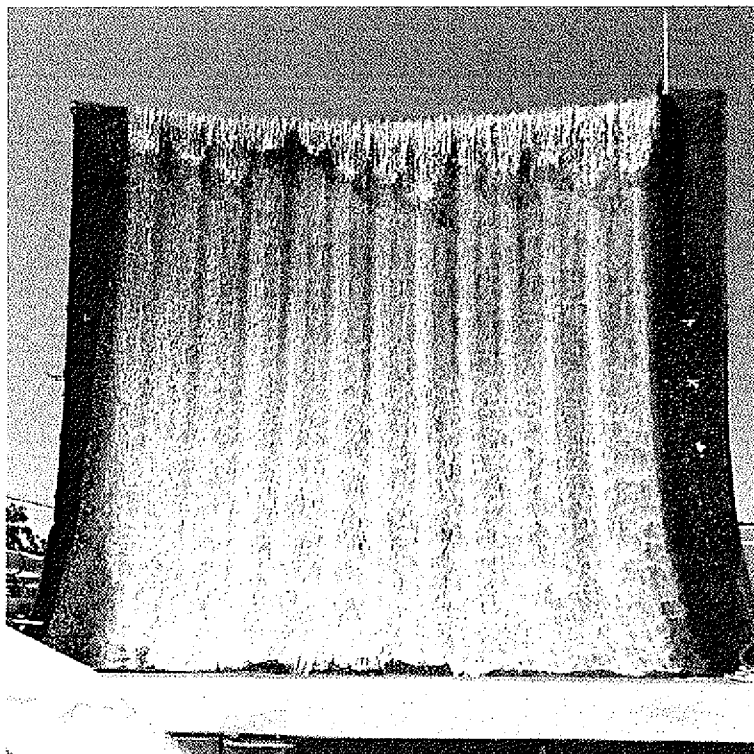


FIGURE 17000

02:21

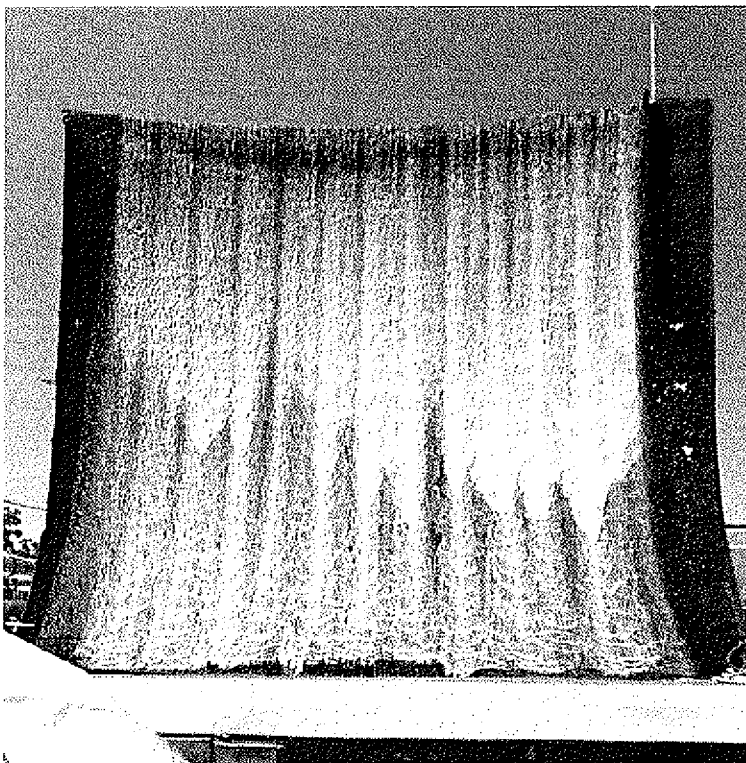


FIGURE 17PPP

02:23

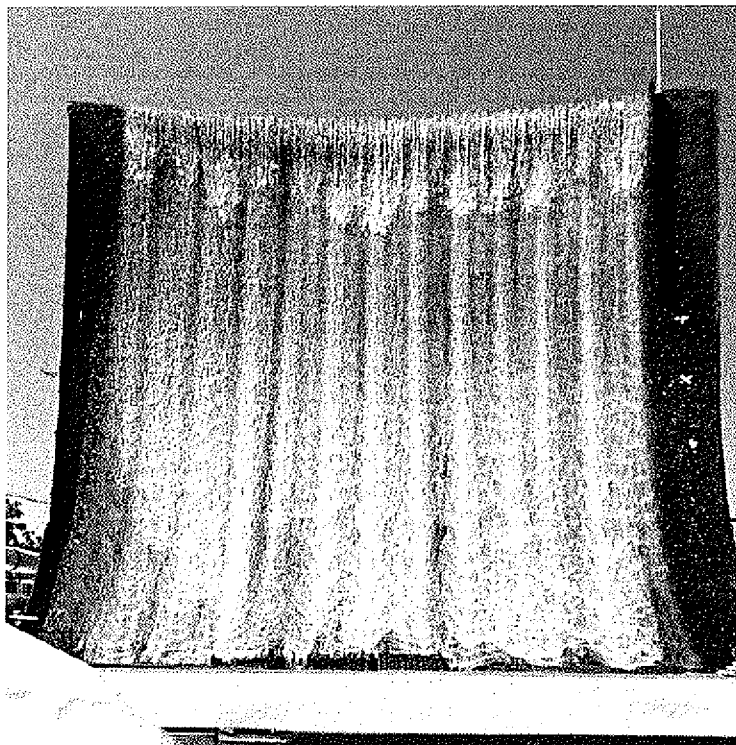


FIGURE 17QQQ

02:25

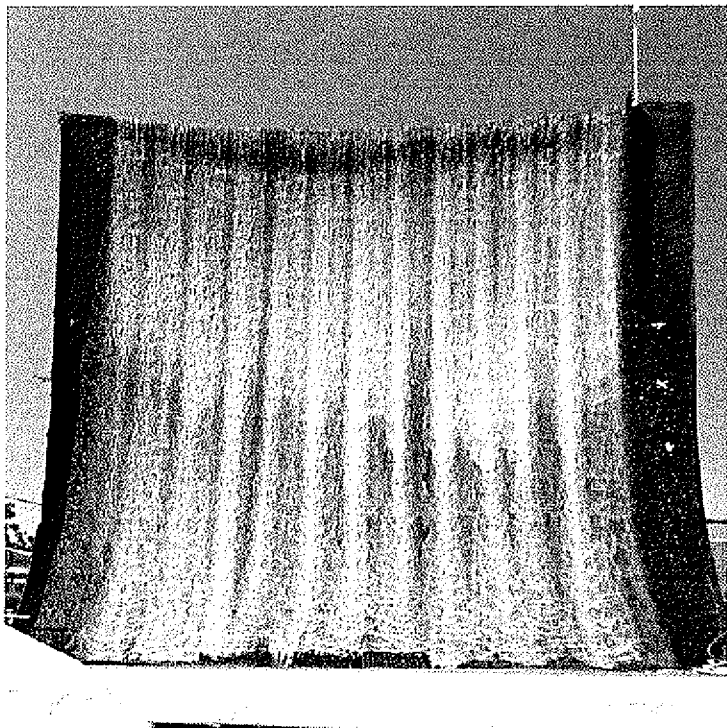


FIGURE 17RRR

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02:27

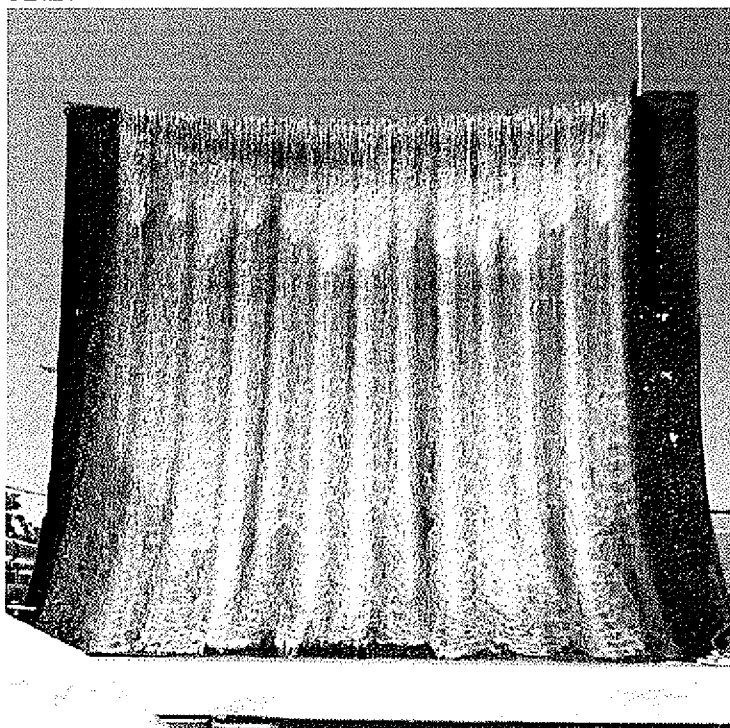


FIGURE 17SSS

02:30

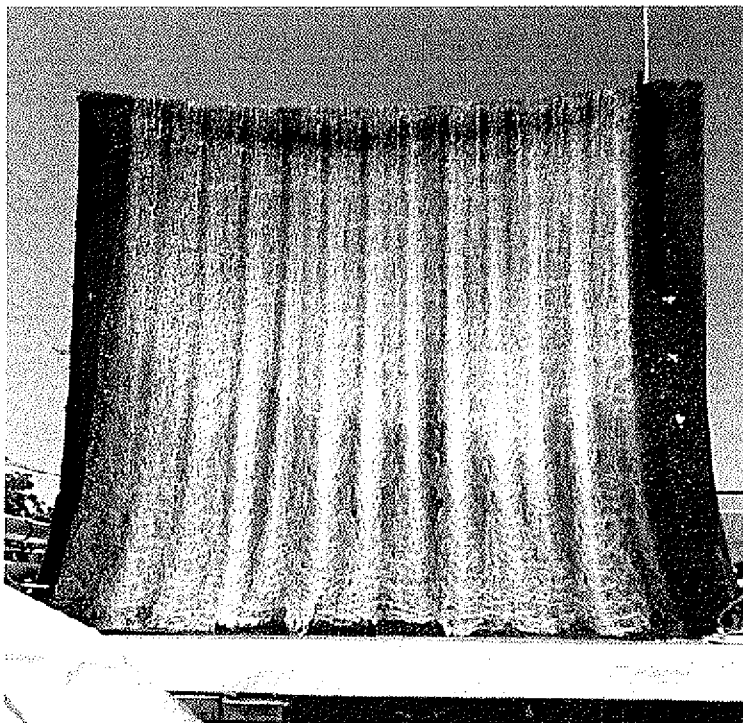


FIGURE 17TTT

02:32

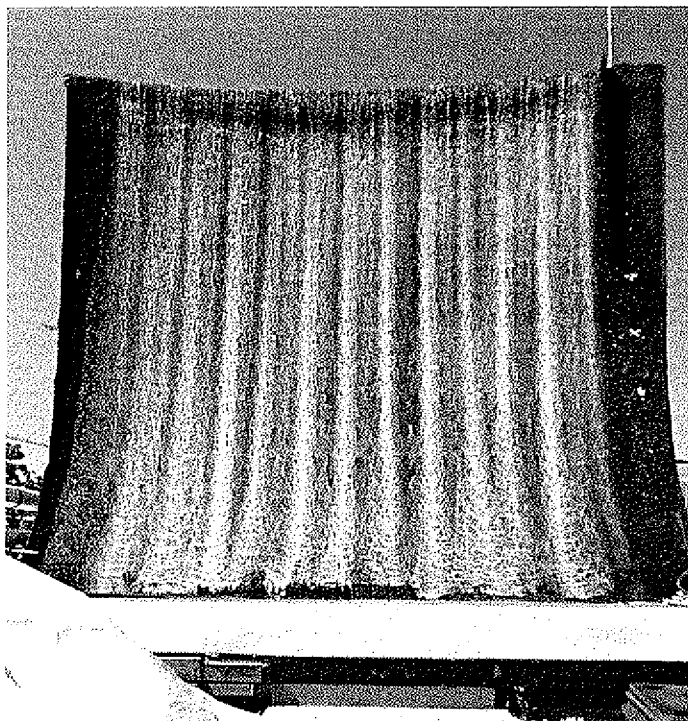


FIGURE 17UUU

02:36

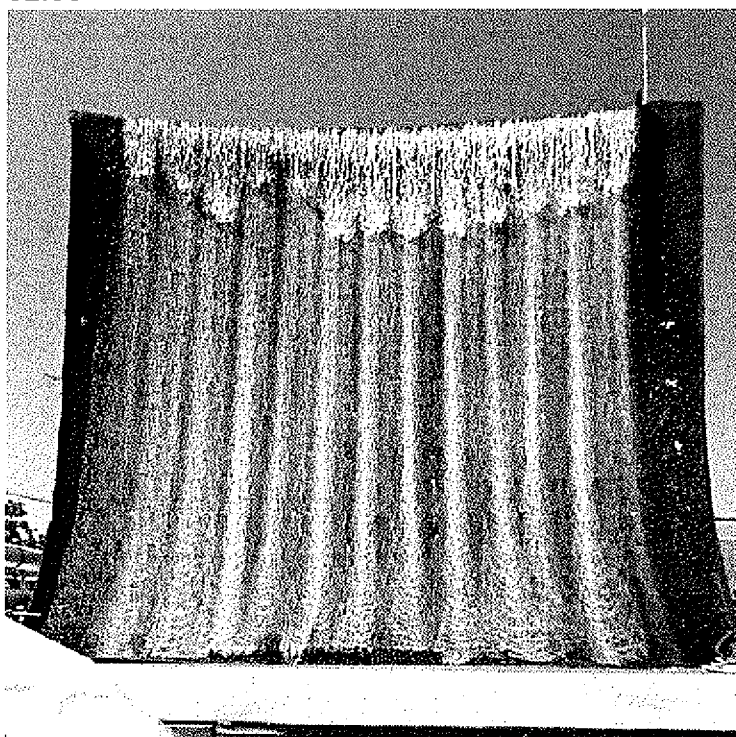


FIGURE 17VVV

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02:37

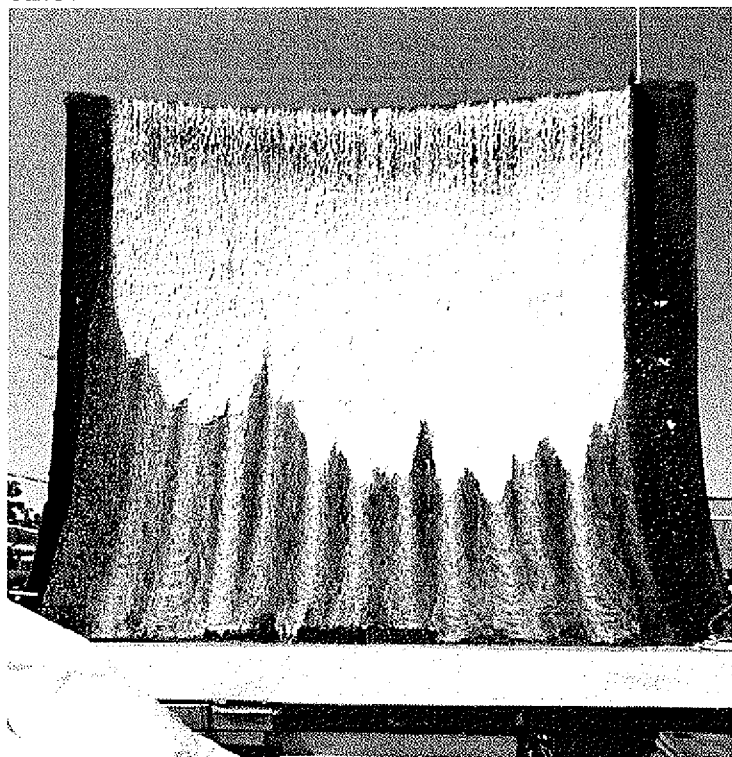


FIGURE 17WWW

02:39

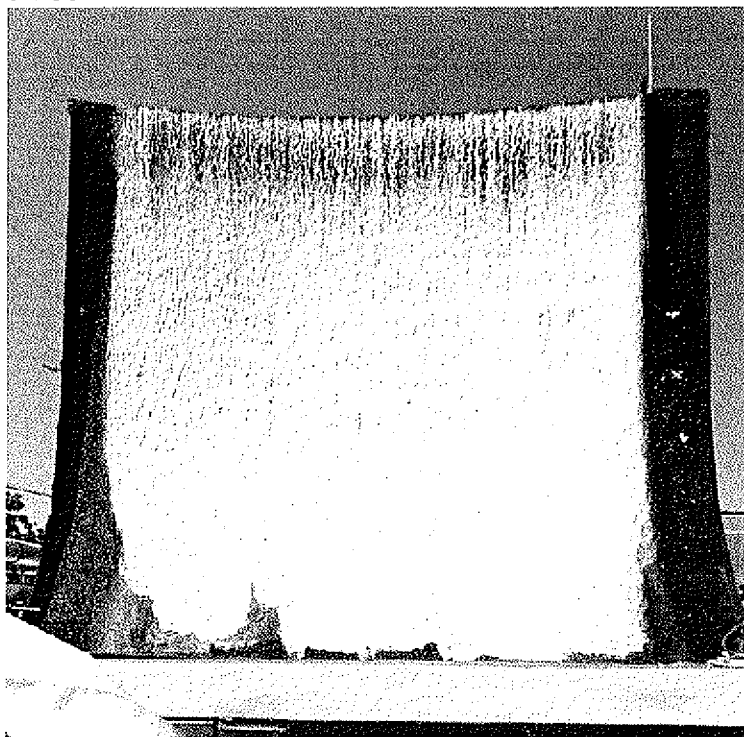


FIGURE 17XXX

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02:41

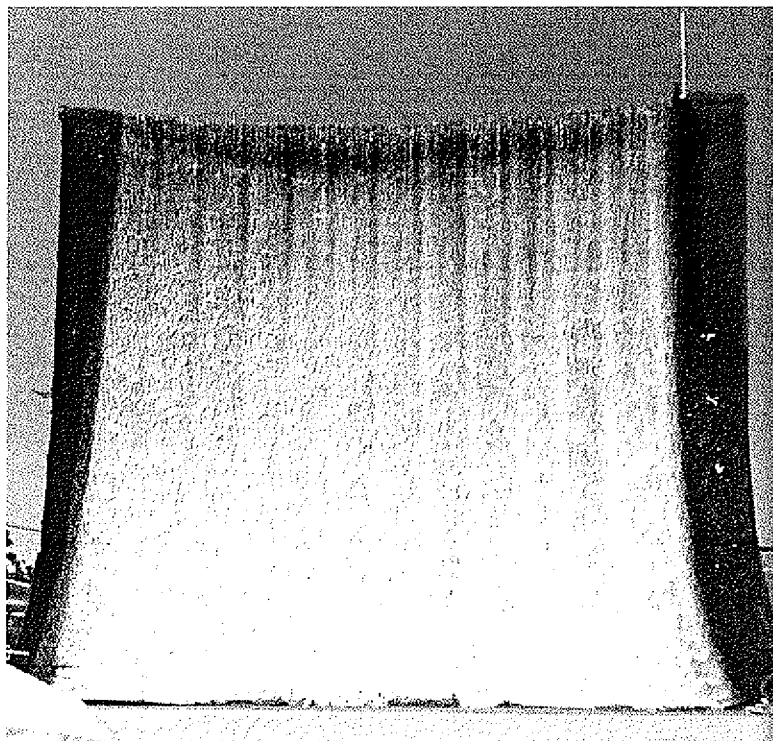


FIGURE 17YYY

02:44

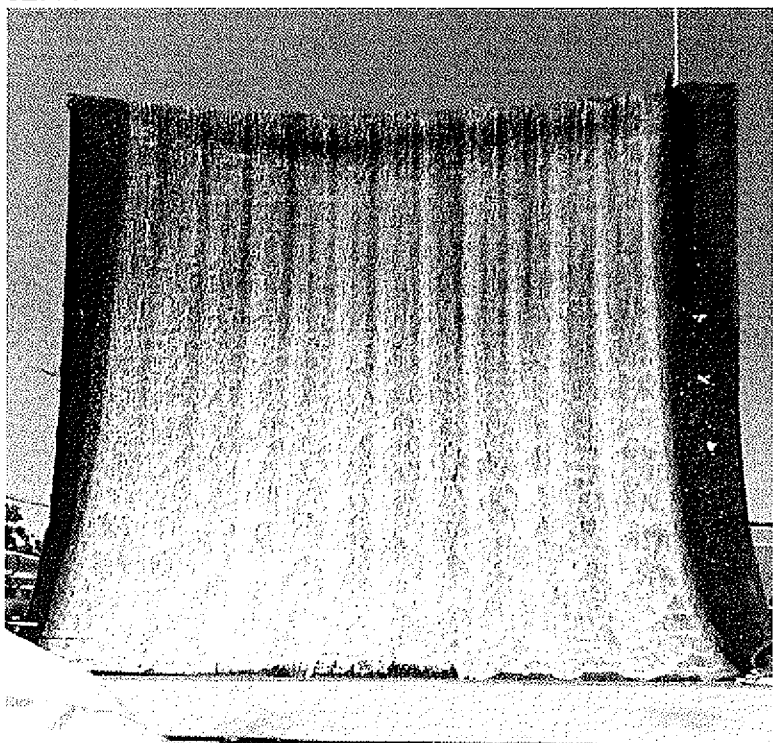


FIGURE 17ZZZ

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02:47

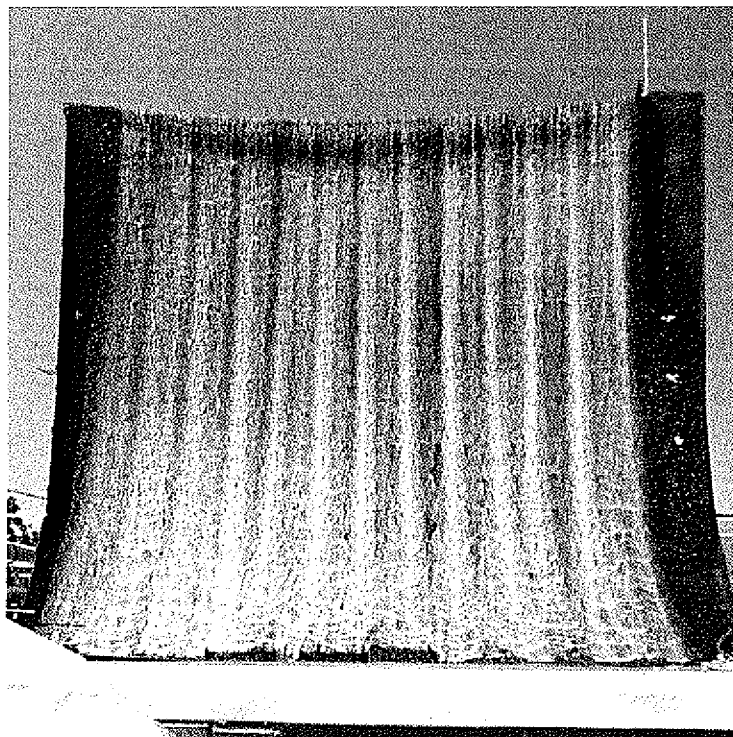


FIGURE 17AAAA

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WET – Stills of Video 10-04-19 213427

00:00



FIGURE 18A

00:01

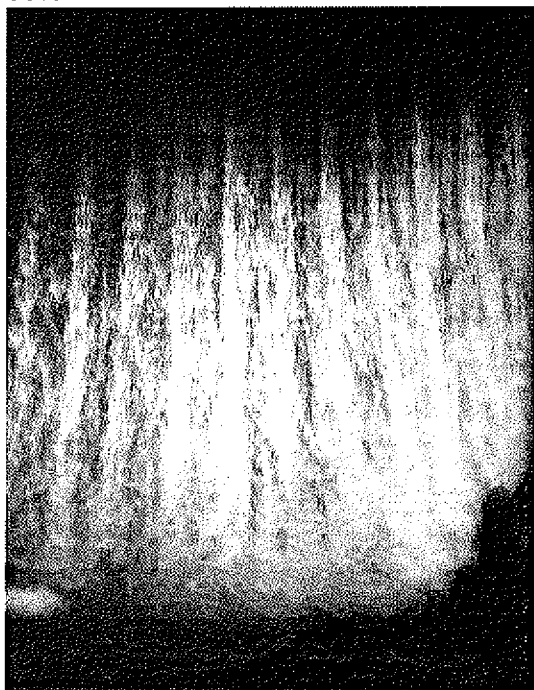


FIGURE 18B

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00:02

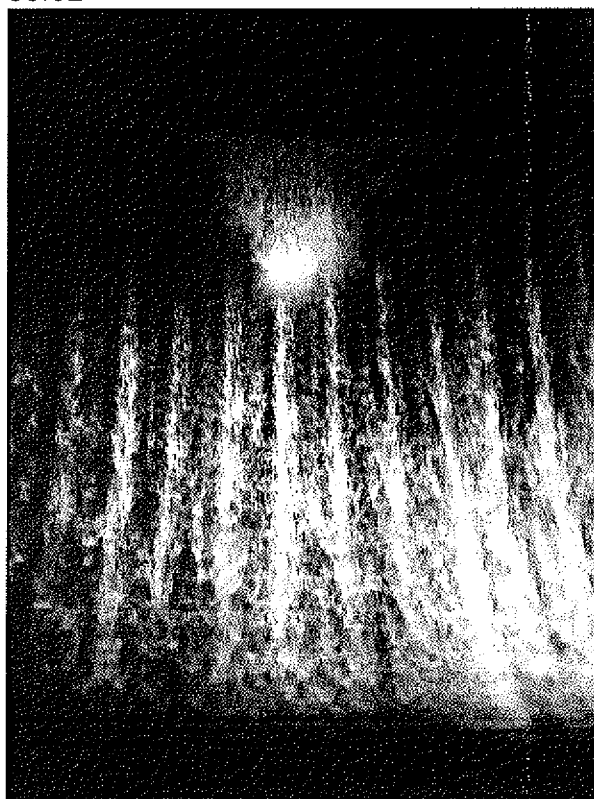


FIGURE 18C

00:03

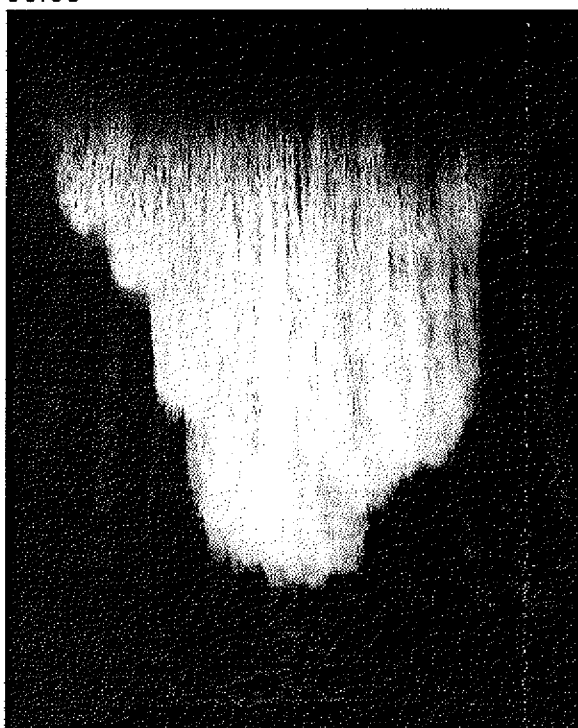


FIGURE 18D

00:05



FIGURE 18E

00:07

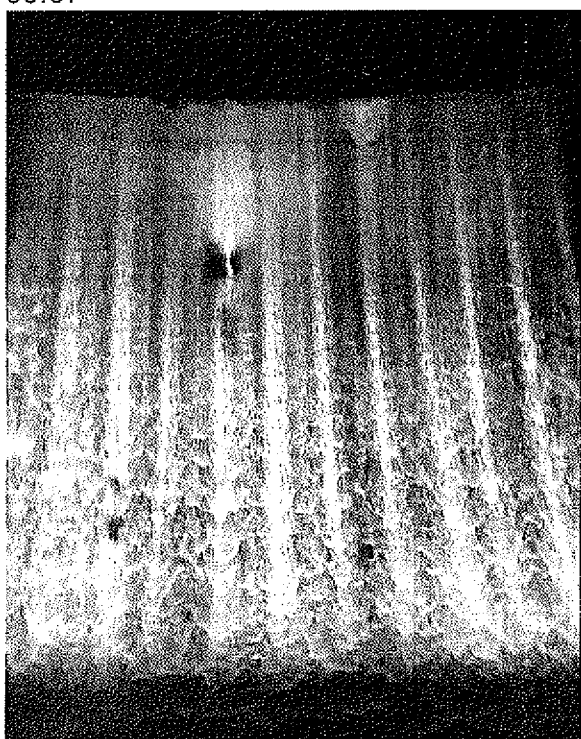


FIGURE 18F

00:08

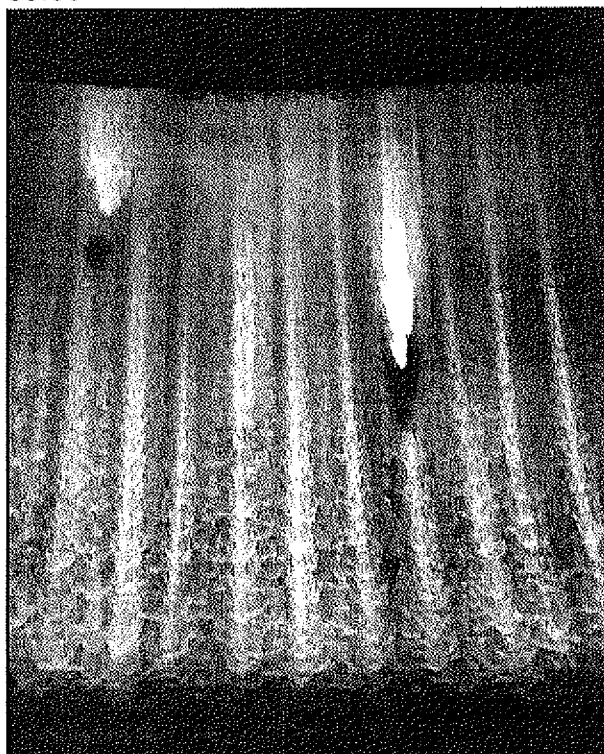


FIGURE 18G

00:09

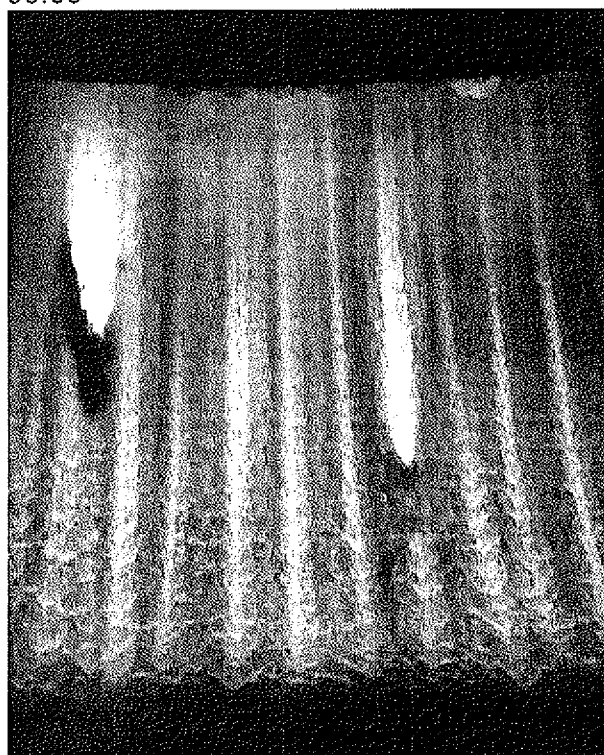


FIGURE 18H

00:10

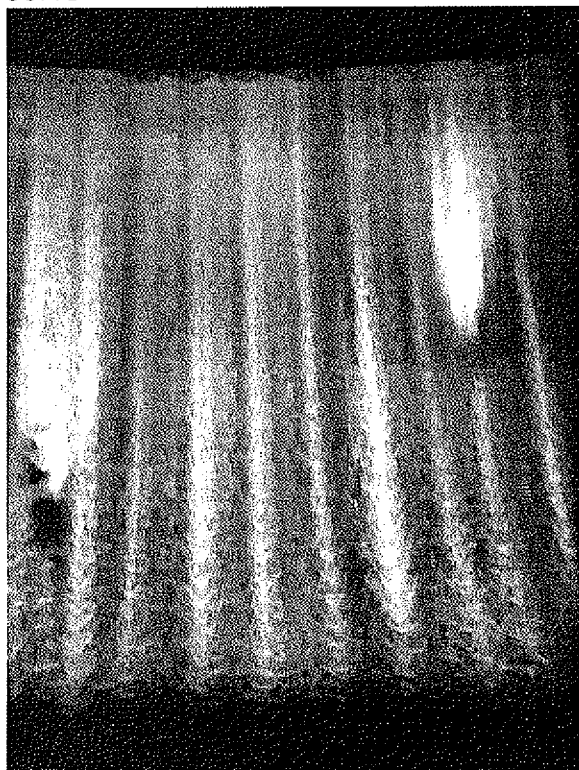


FIGURE 18I

00:11

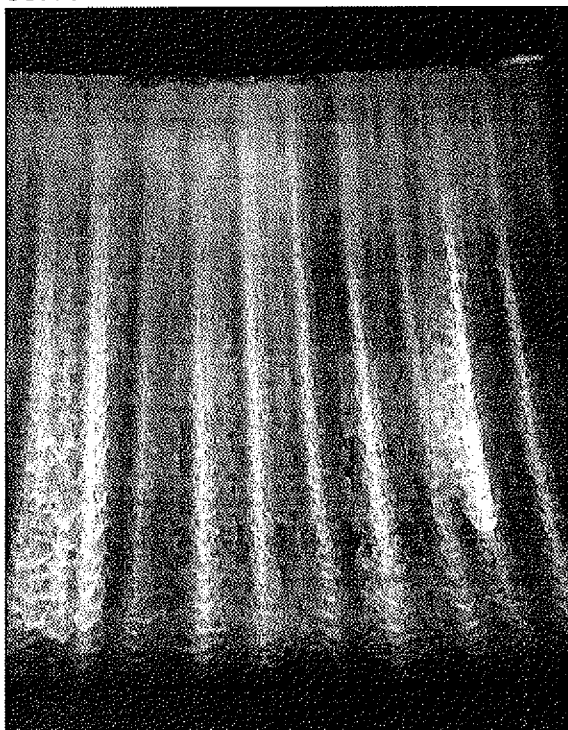


FIGURE 18J

00:12

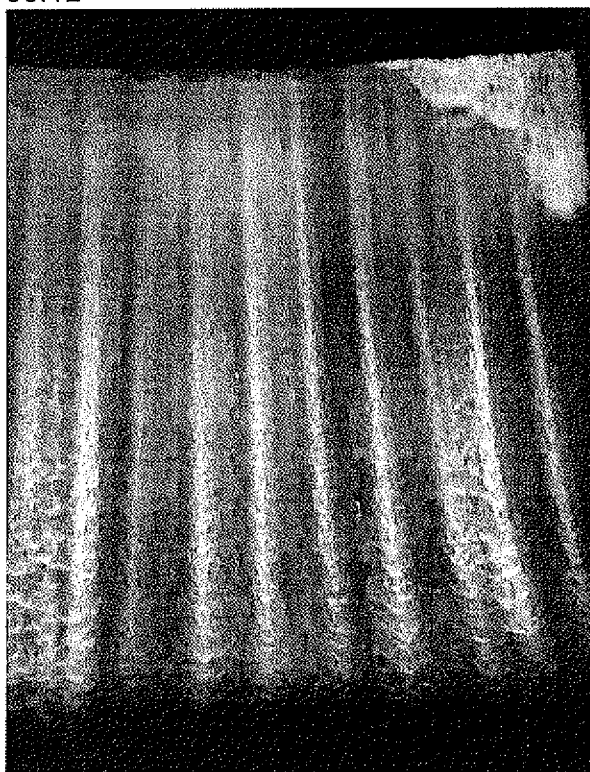


FIGURE 18K

00:13



FIGURE 18L

00:14



FIGURE 18M

00:15

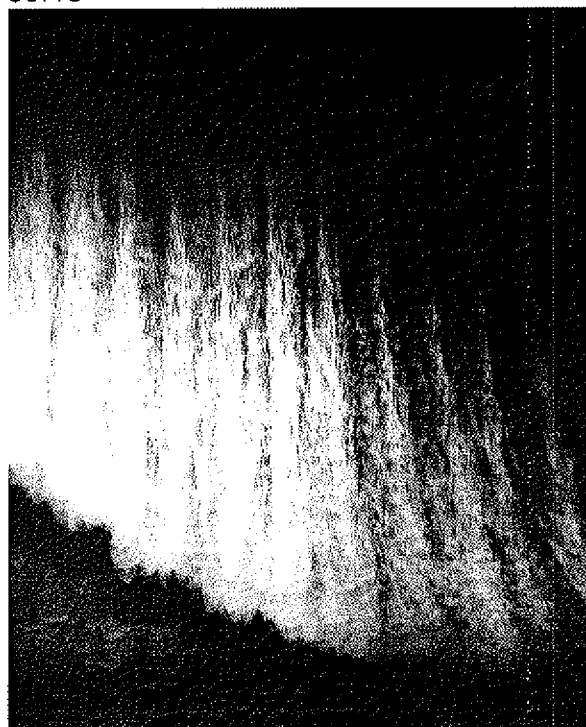


FIGURE 18N

00:16

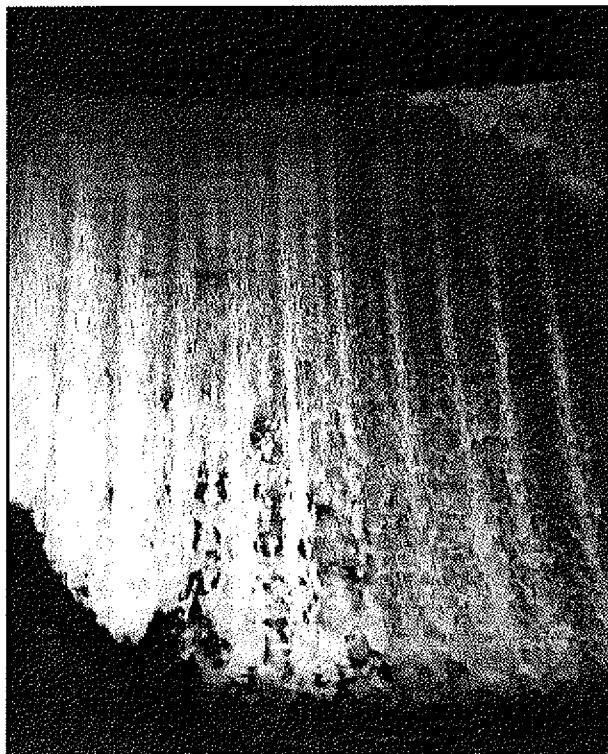


FIGURE 18O

00:17

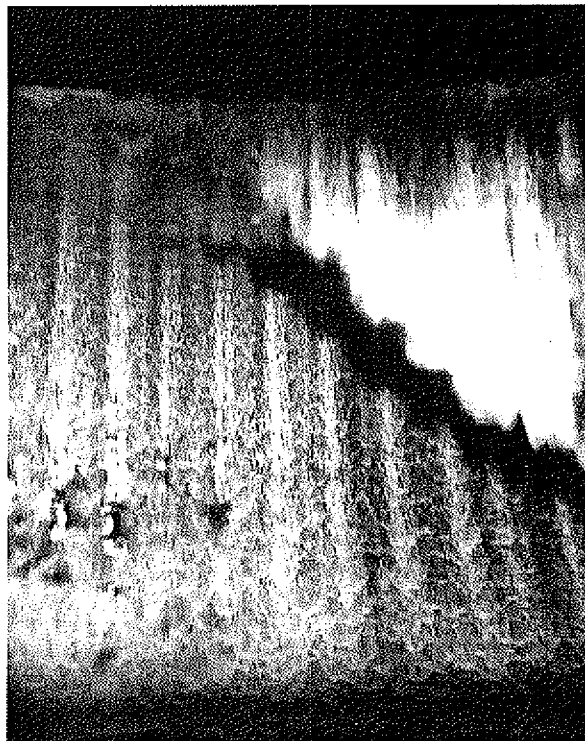


FIGURE 18P

00:18



FIGURE 18Q

00:19

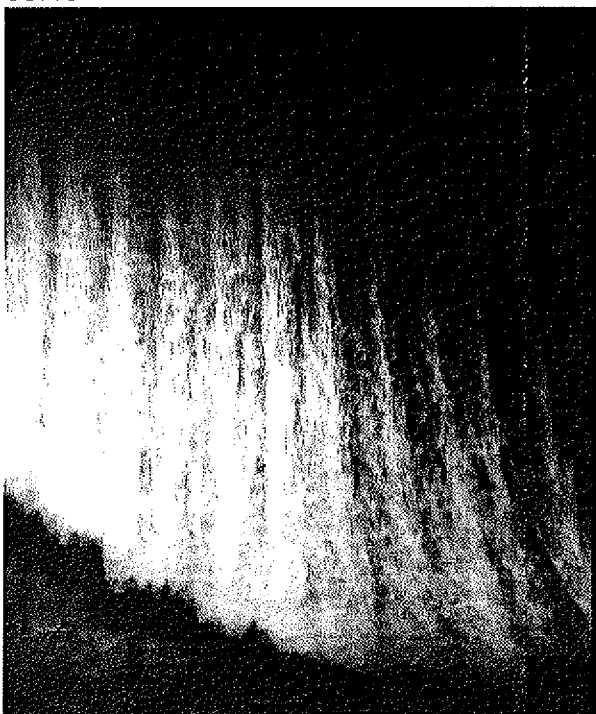


FIGURE 18R

00:20

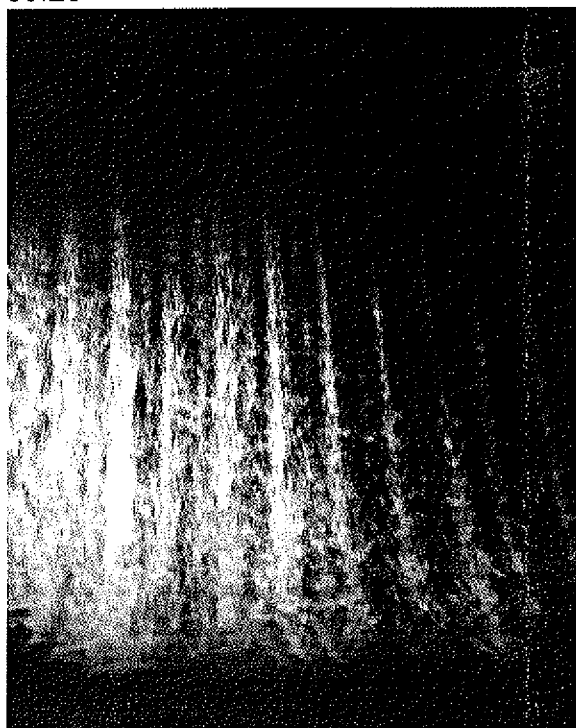


FIGURE 18S

00:20



FIGURE 18T

00:22

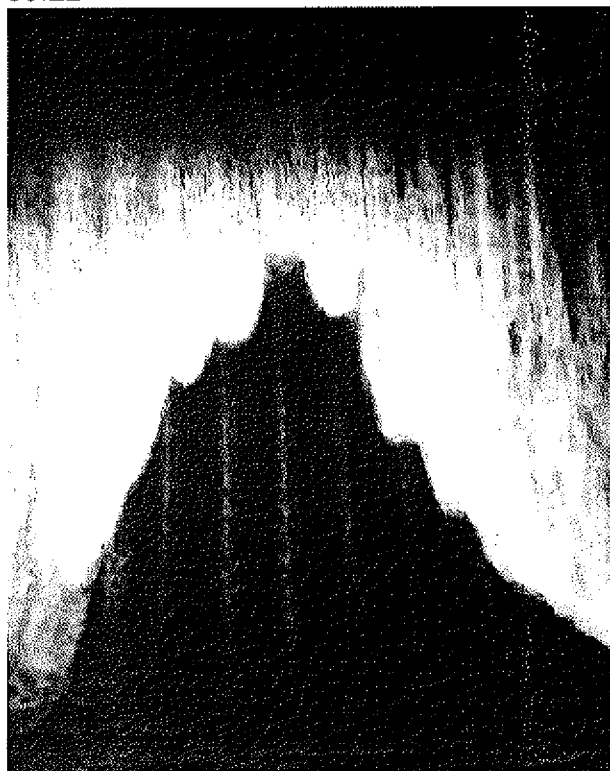


FIGURE 18U

00:23

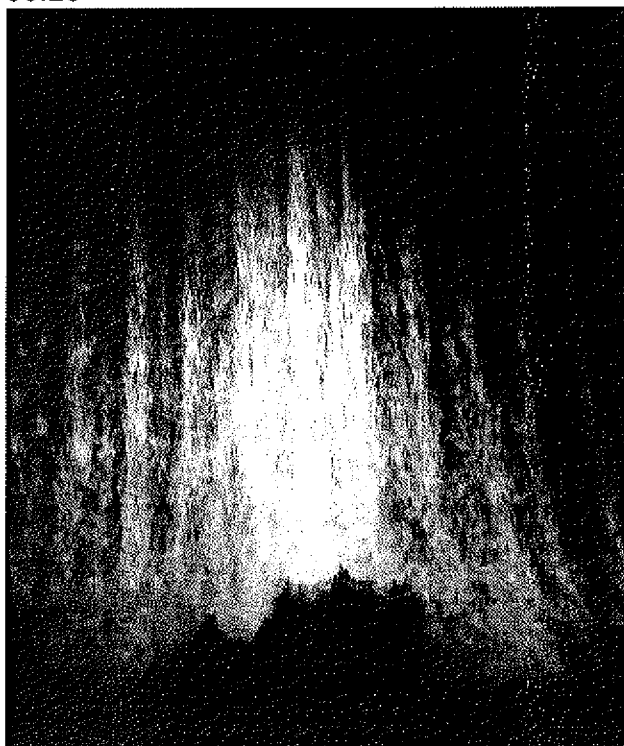


FIGURE 18V

00:24

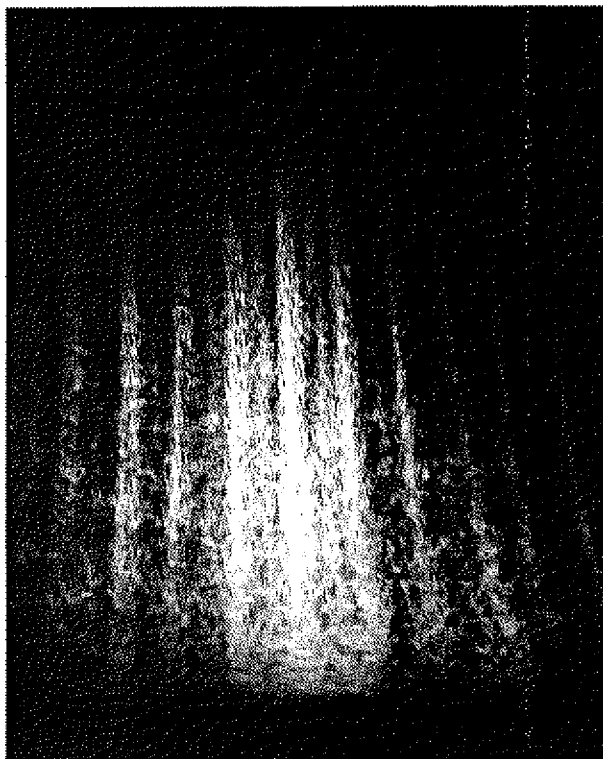


FIGURE 18W

00:25

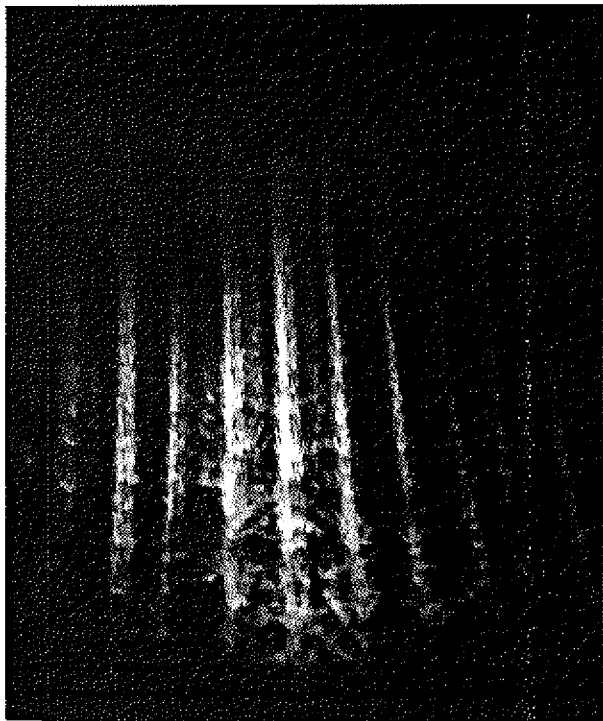


FIGURE 18X

00:26



FIGURE 18Y

00:26

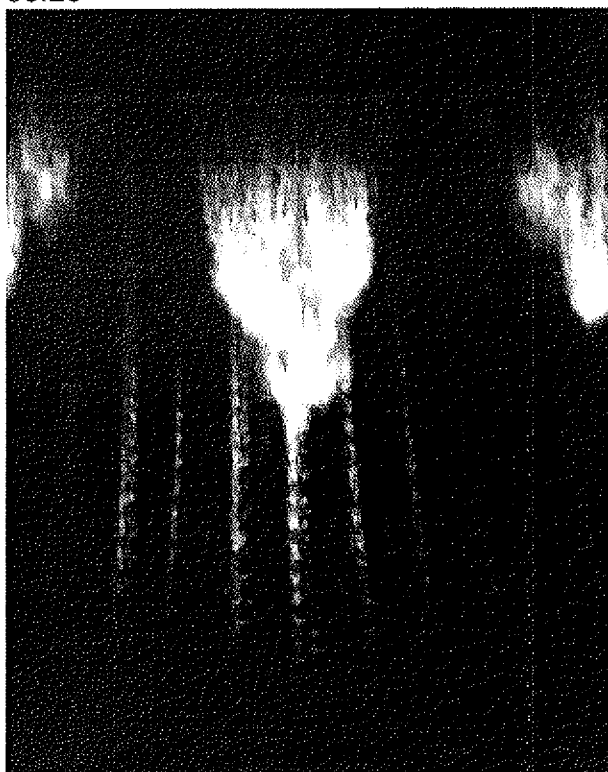


FIGURE 18Z

00:27



FIGURE 18AA

00:28

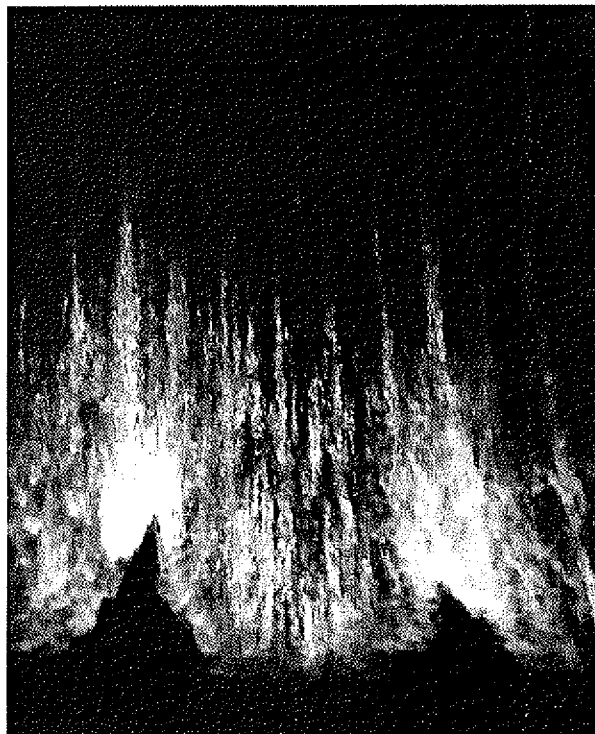


FIGURE 18BB

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00:30

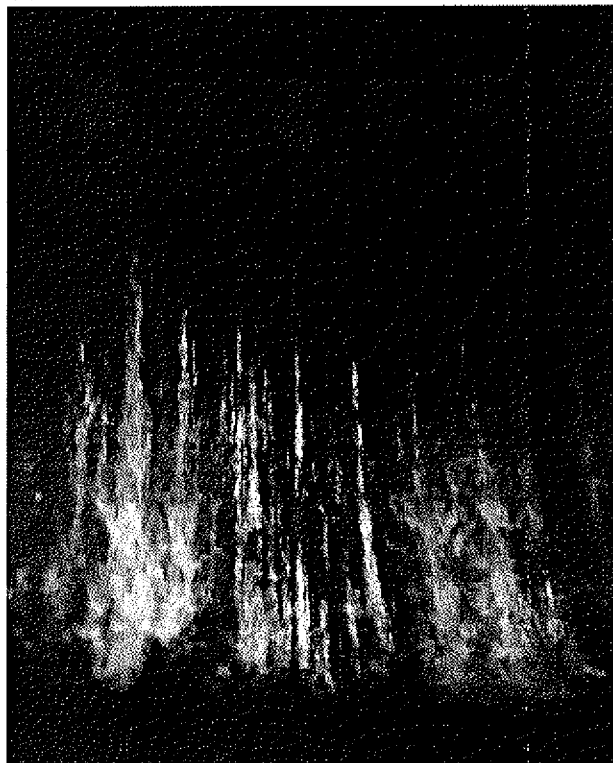


FIGURE 18CC

00:30

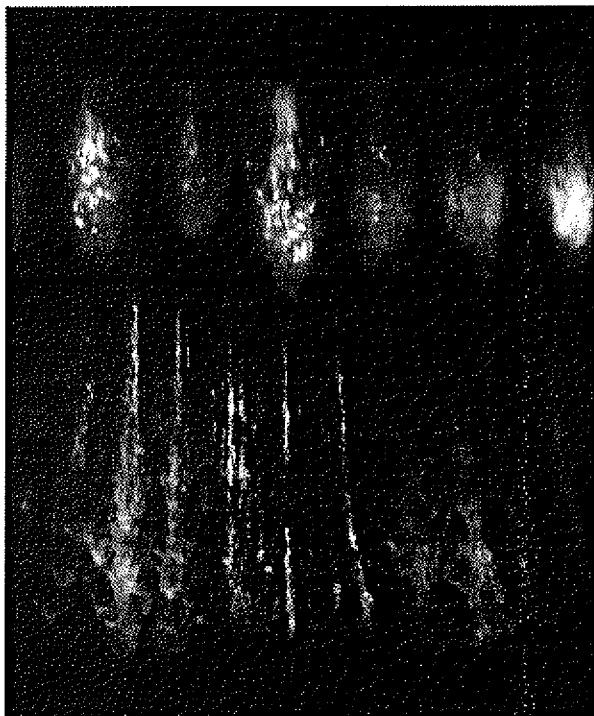


FIGURE 18DD

00:31

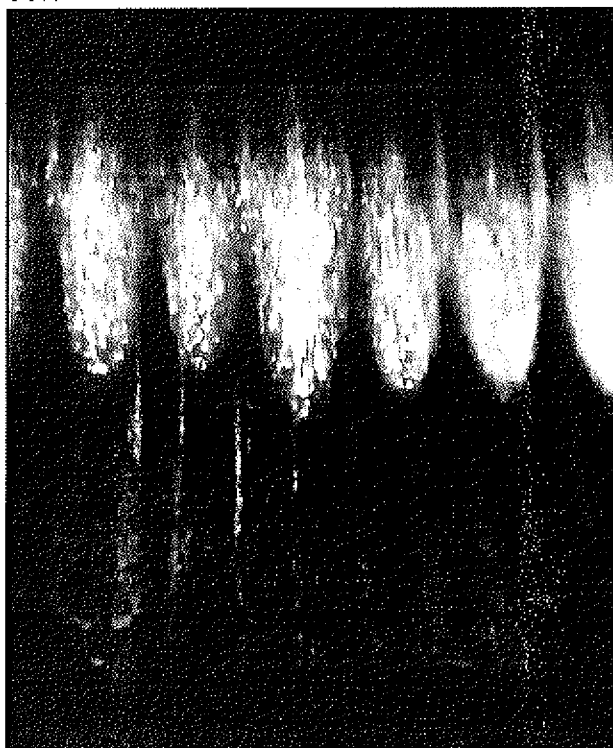


FIGURE 18EE

00:32

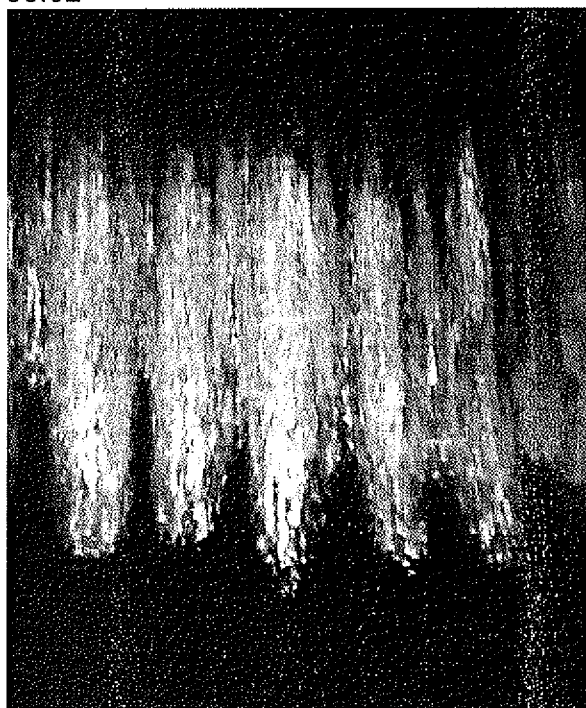


FIGURE 18FF

00:33

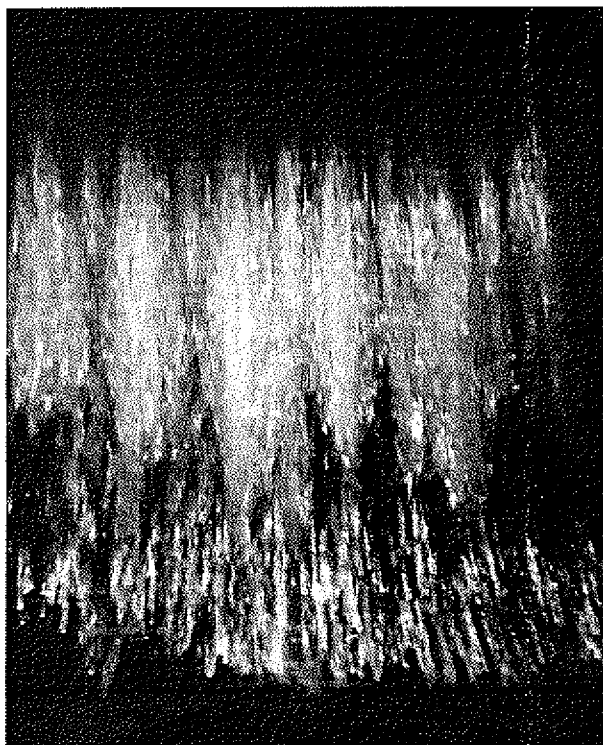


FIGURE 18GG

00:34

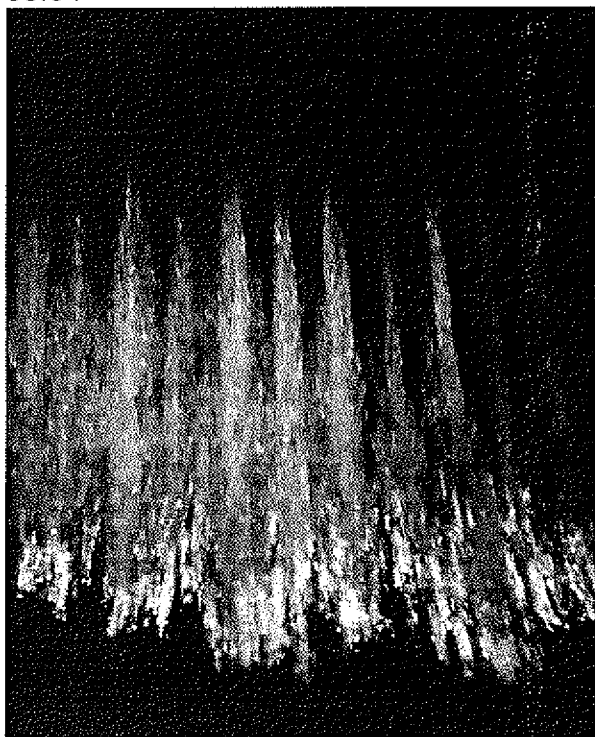


FIGURE 18HH

00:35

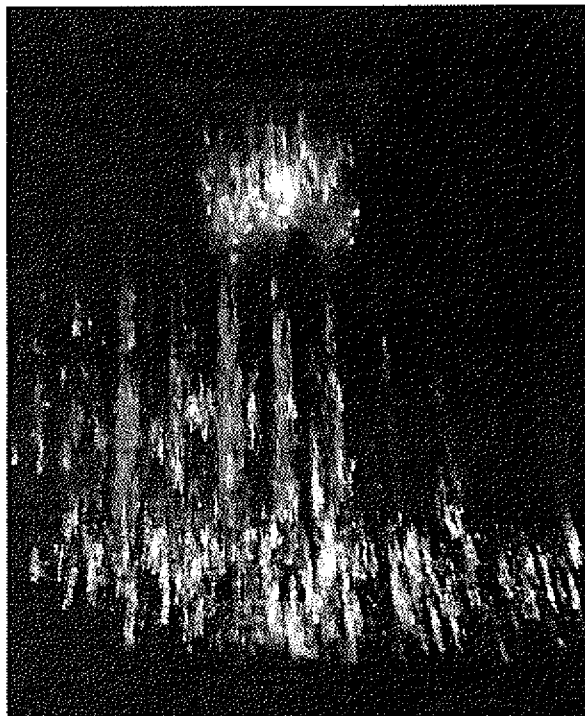


FIGURE 18II

00:35

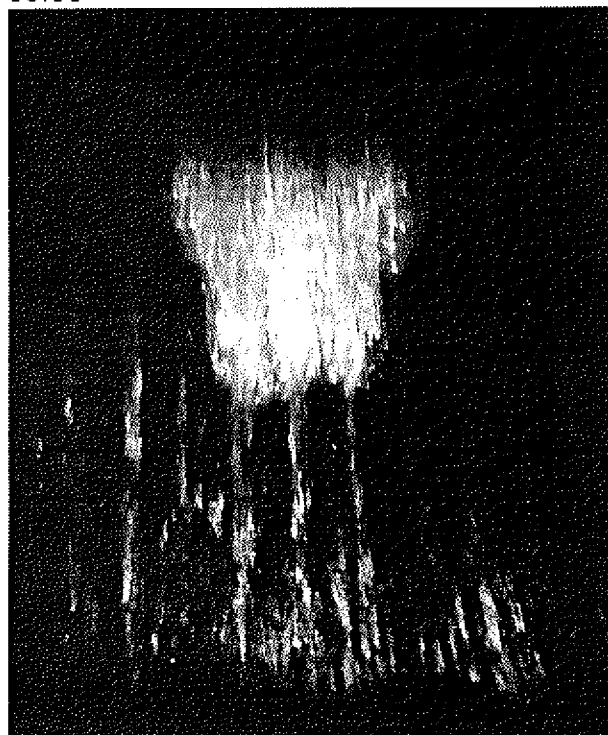


FIGURE 18JJ

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00:36

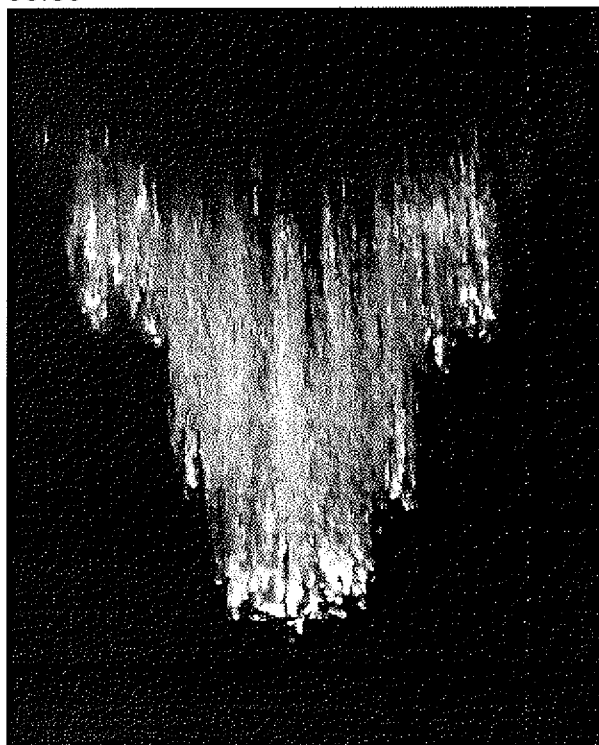


FIGURE 18KK

00:37

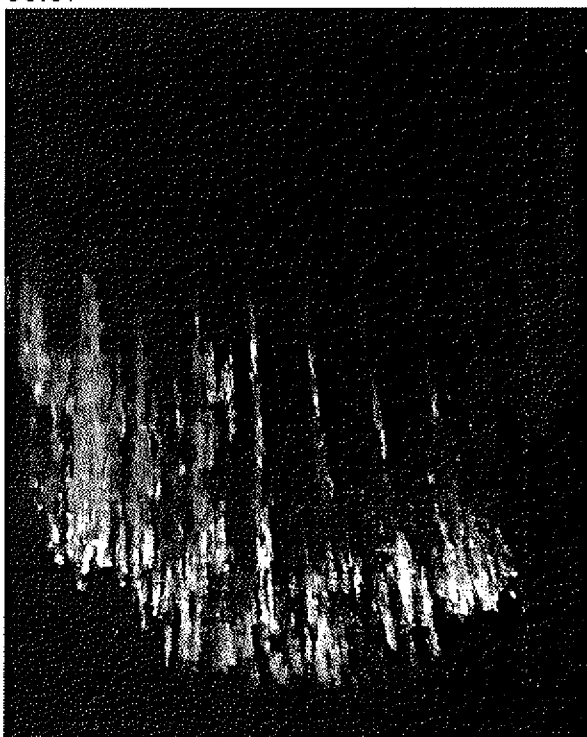


FIGURE 18LL

00:37

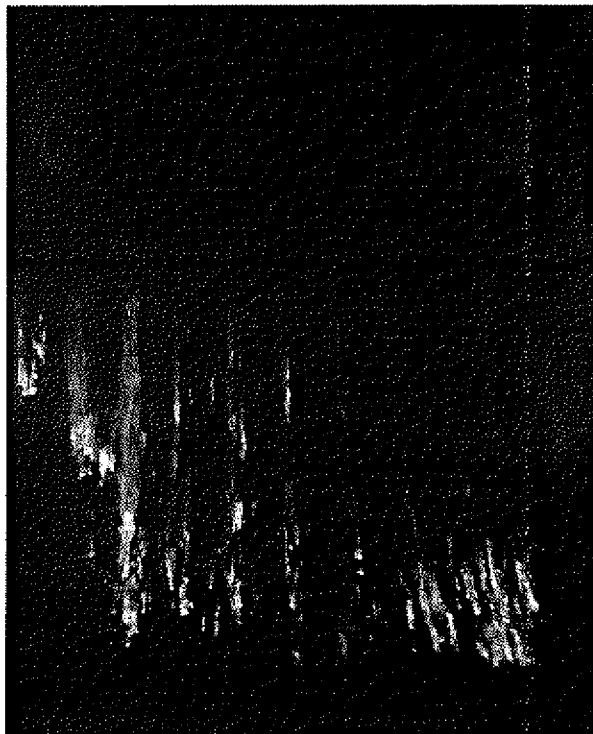


FIGURE 18MM

00:38

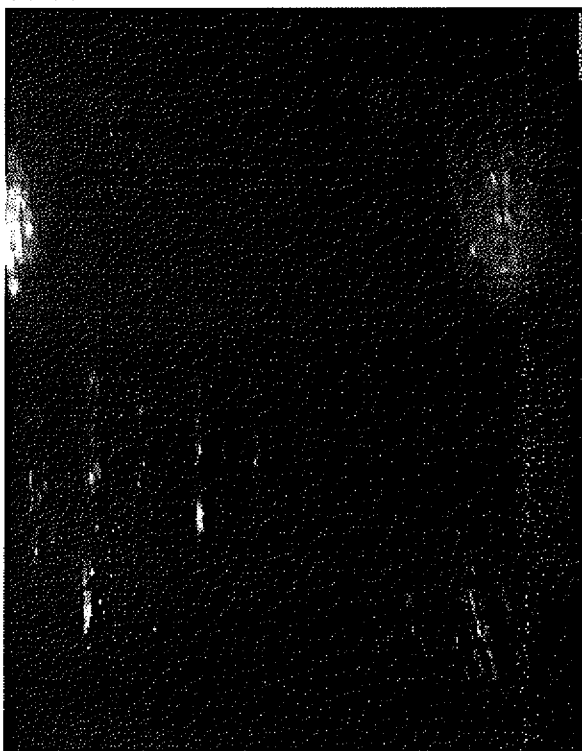


FIGURE 18NN

00:38

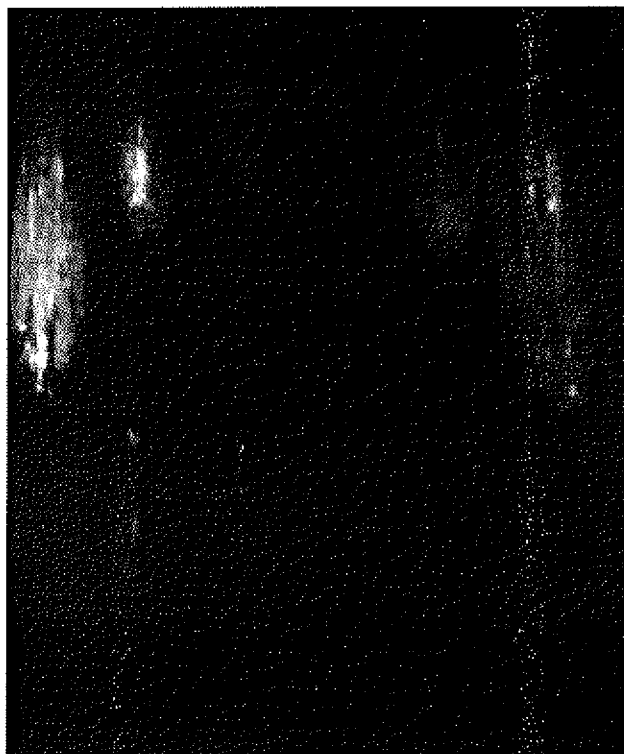


FIGURE 1800

00:39

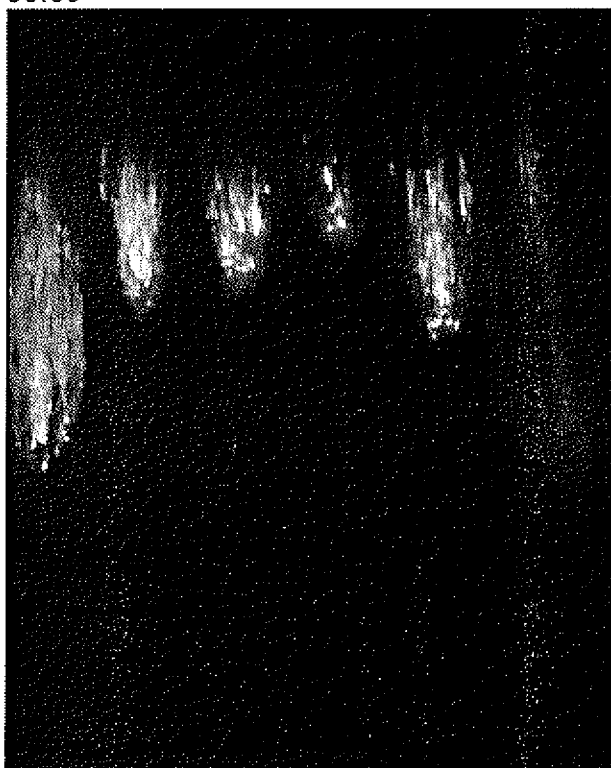


FIGURE 18PP

00:39



FIGURE 18QQ

00:40



FIGURE 18RR

00:40



FIGURE 18SS

00:41

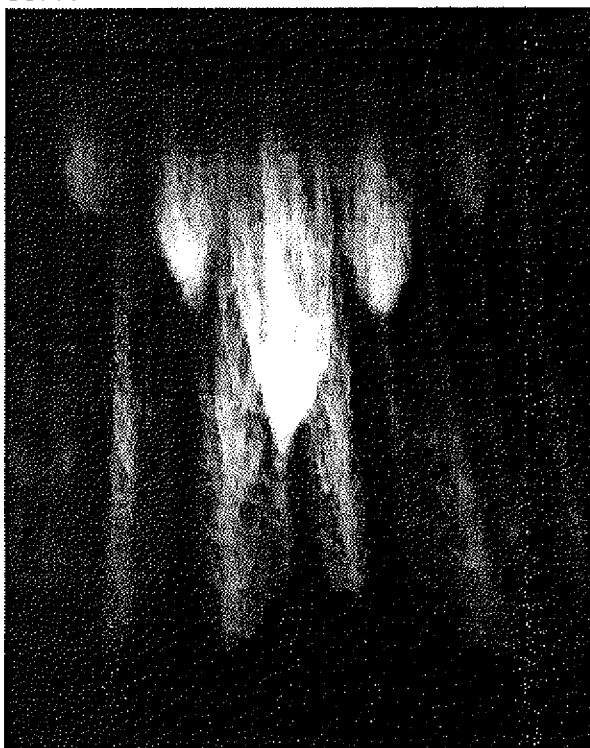


FIGURE 18TT

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00:42

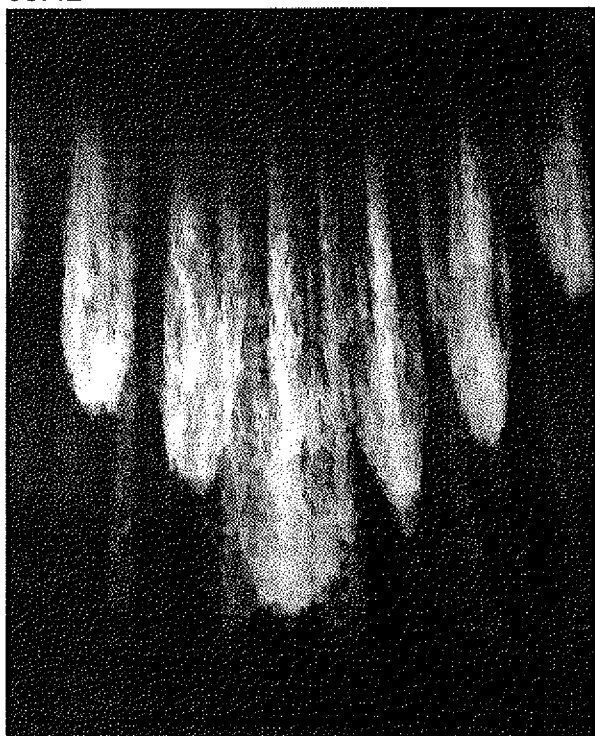


FIGURE 18UU

00:42

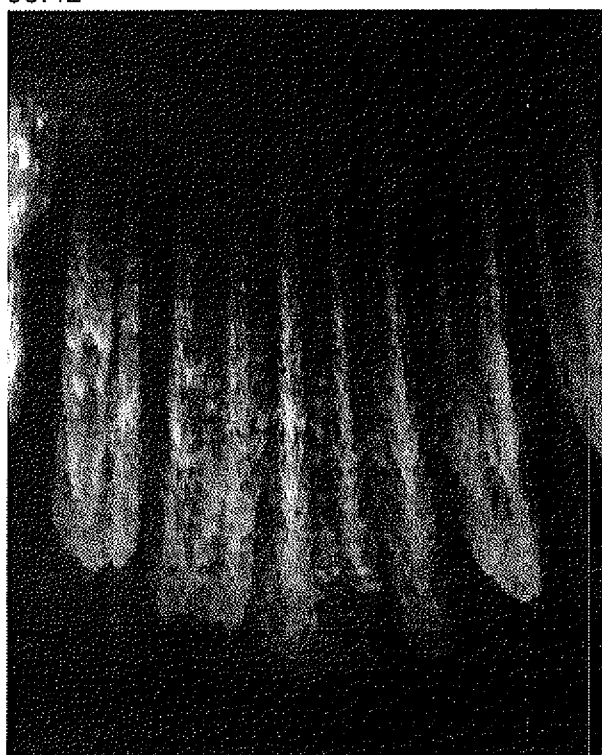


FIGURE 18VV

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00:43

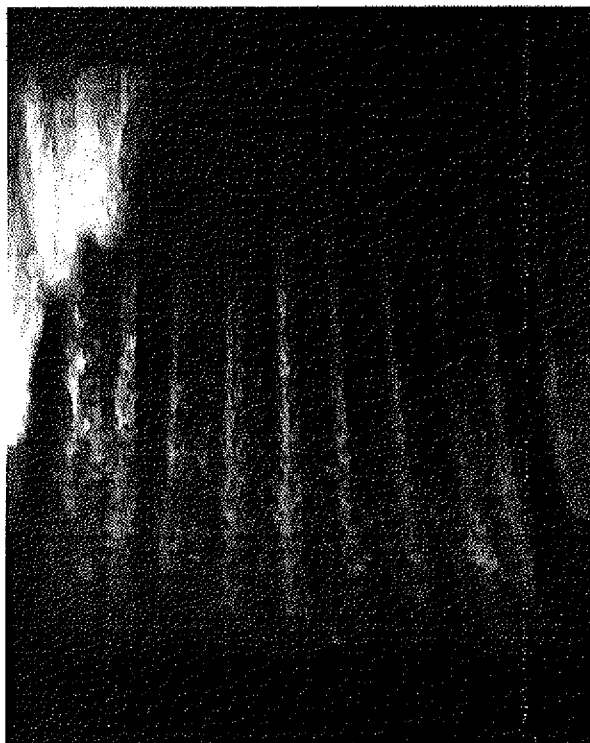


FIGURE 18WW

00:44



FIGURE 18XX

00:45

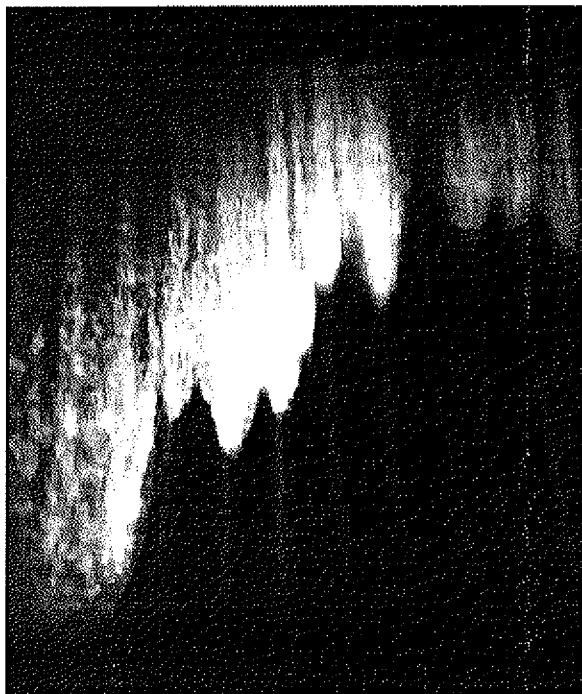


FIGURE 18YY

00:46

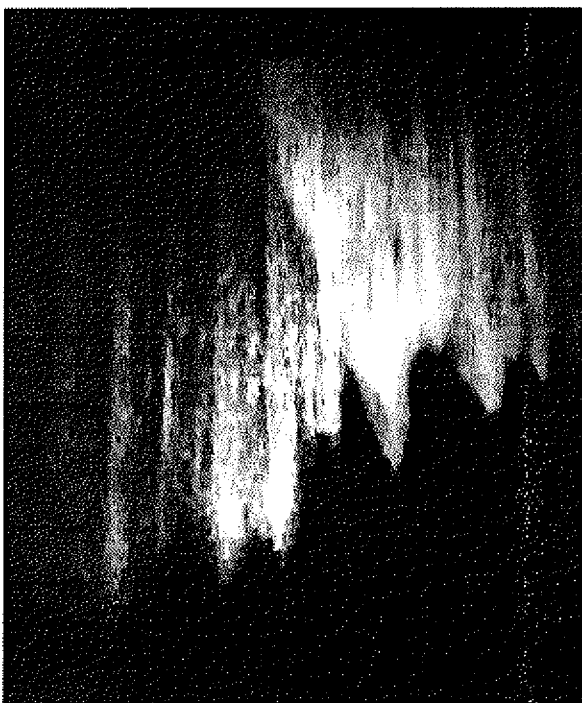


FIGURE 18ZZ

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00:46

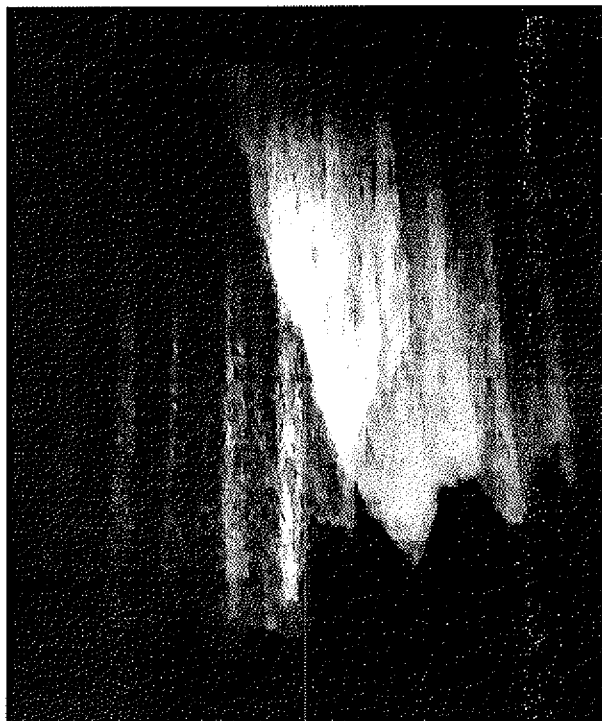


FIGURE 18AAA

00:47

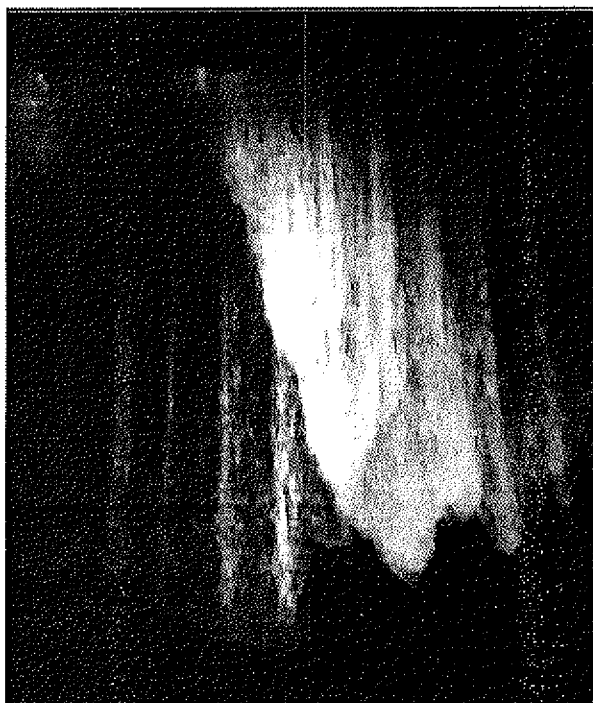


FIGURE 18BBB

00:47

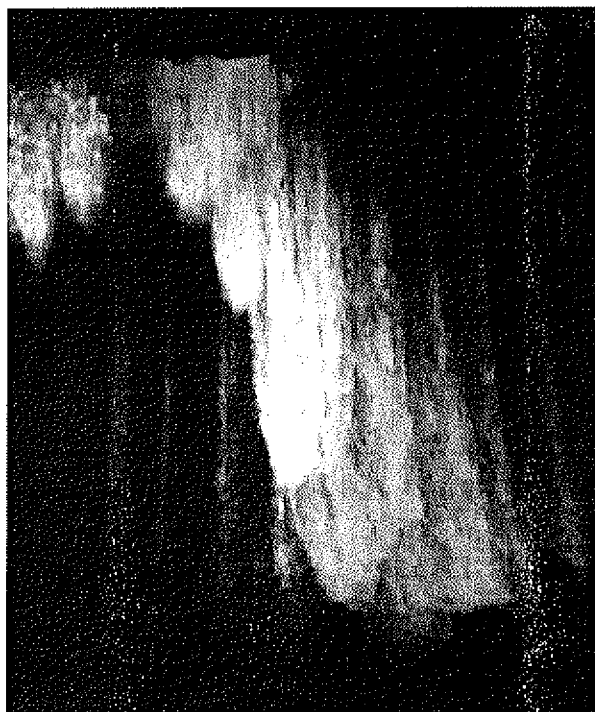


FIGURE 18CCC

00:48

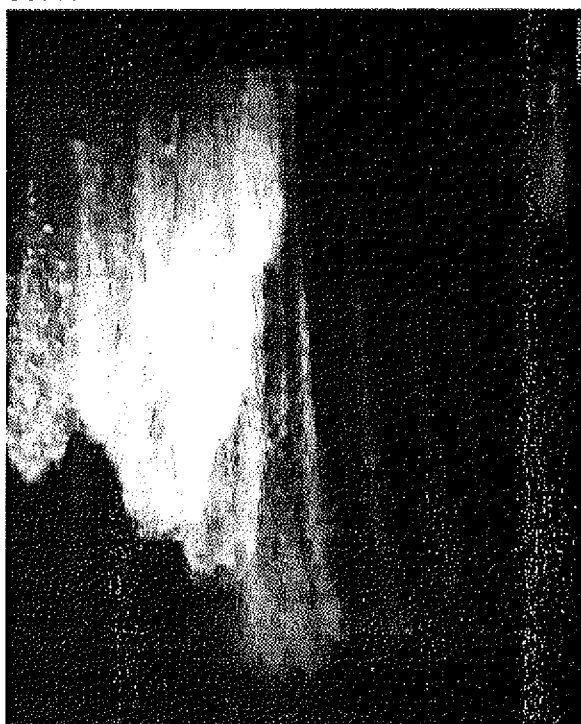


FIGURE 18DDD

00:49



FIGURE 18EEE

00:50



FIGURE 18FFF

00:50

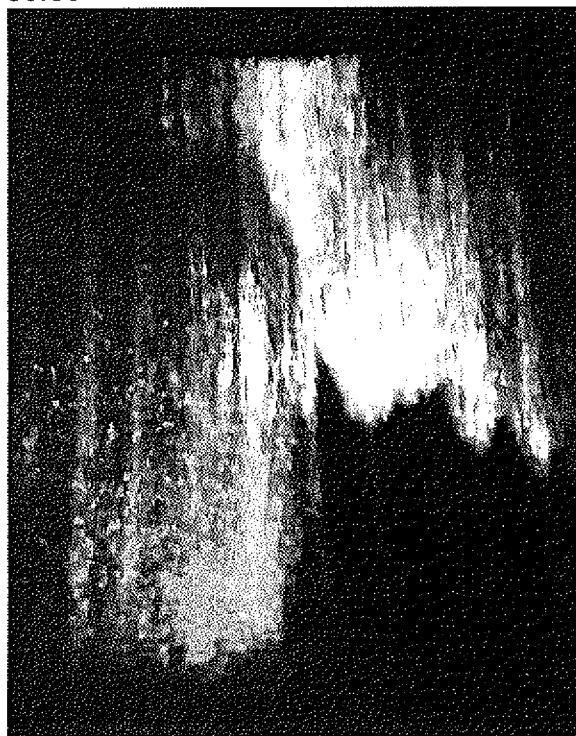


FIGURE 18GGG

00:50

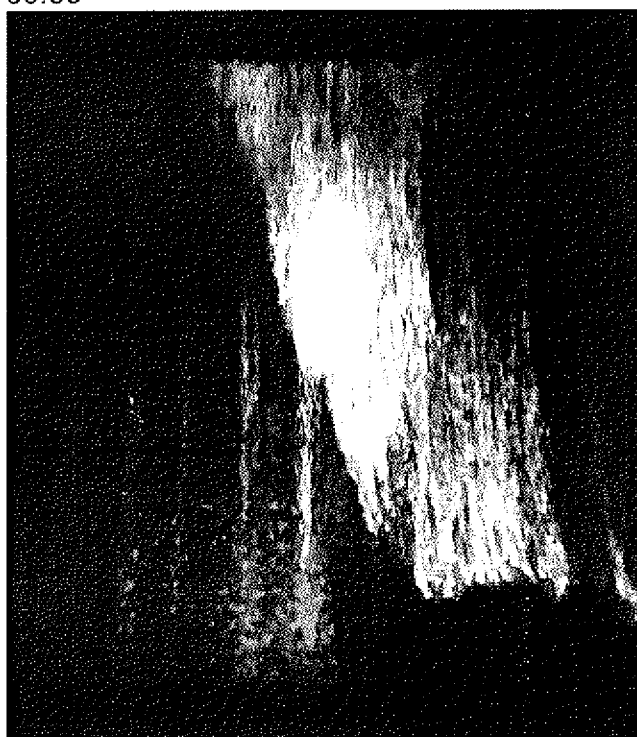


FIGURE 18HHH

00:51

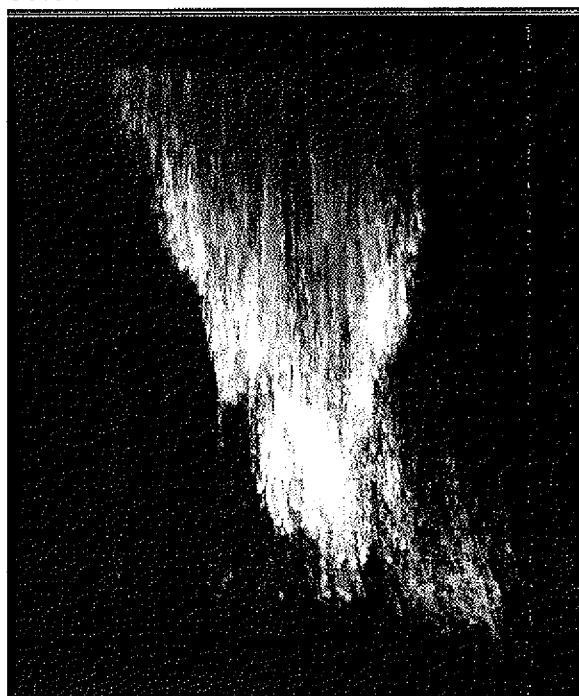


FIGURE 18III

00:52

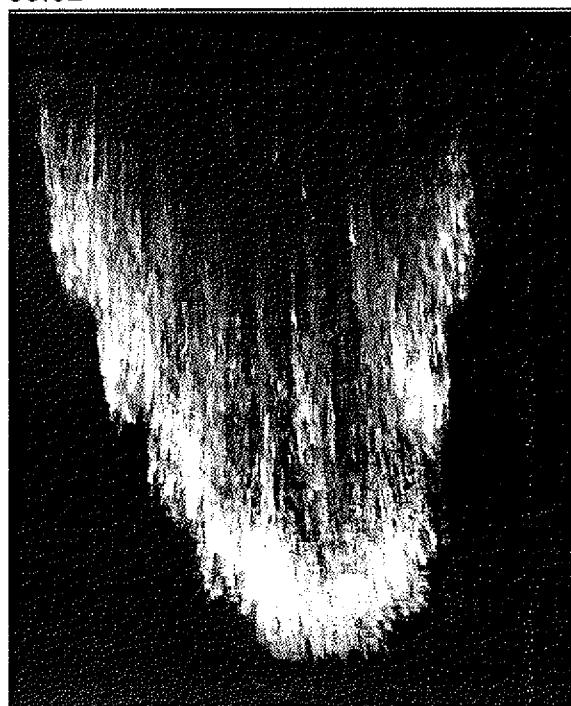


FIGURE 18JJJ

00:53

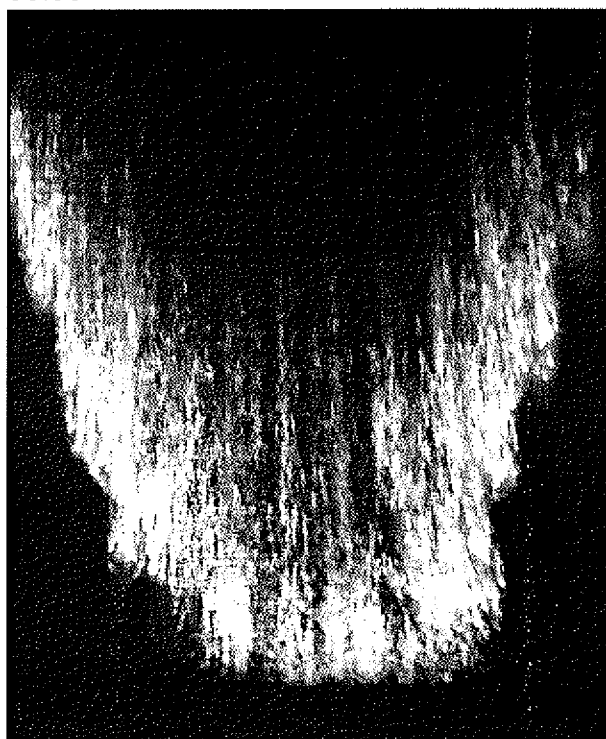


FIGURE 18KKK

00:54



FIGURE 18LLL

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00:54



FIGURE 18MMM

00:55



FIGURE 18NNN

00:55



FIGURE 18000

00:56



FIGURE 18PPP

00:57



FIGURE 18QQQ

00:57



FIGURE 18RRR

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00:58



FIGURE 18SSS

00:59



FIGURE 18TTT

00:59



FIGURE 18UUU

01:00

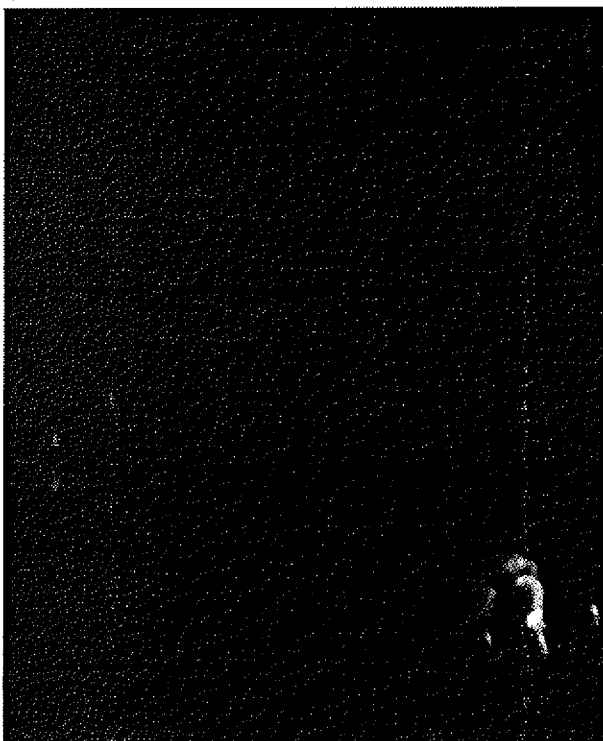


FIGURE 18VVV

01:00

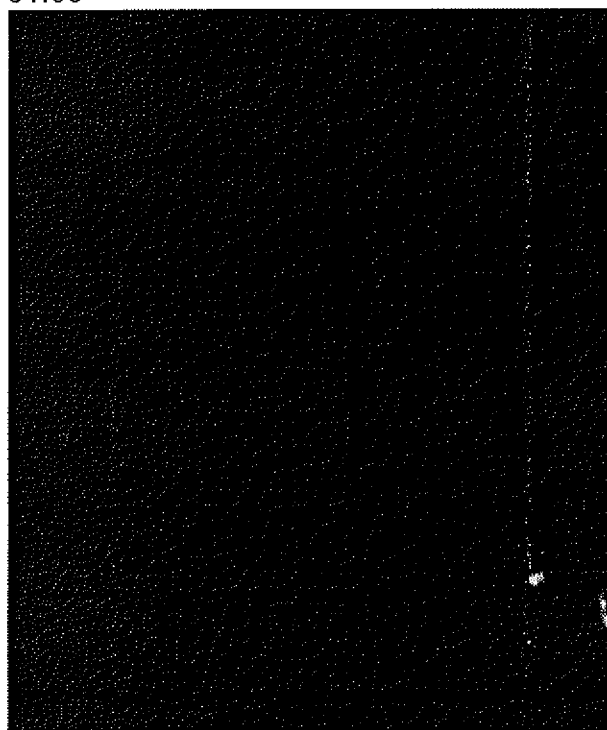


FIGURE 18WWW

01:02

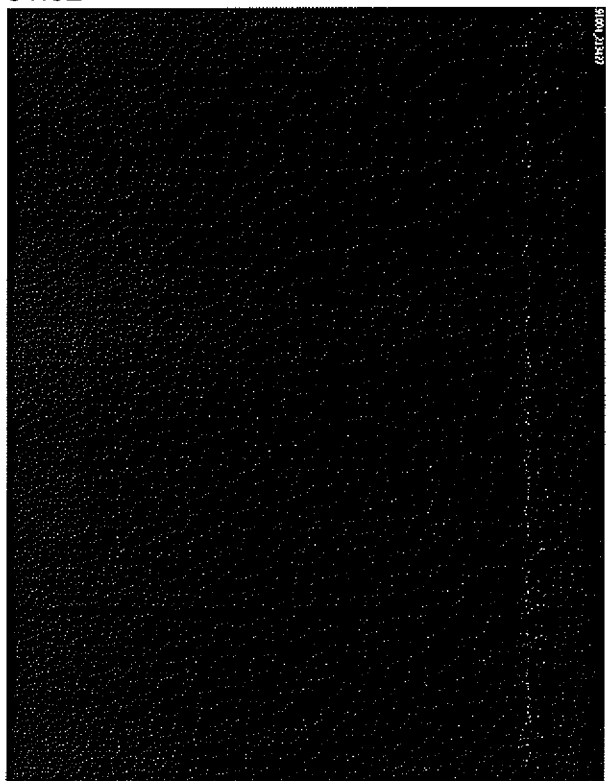
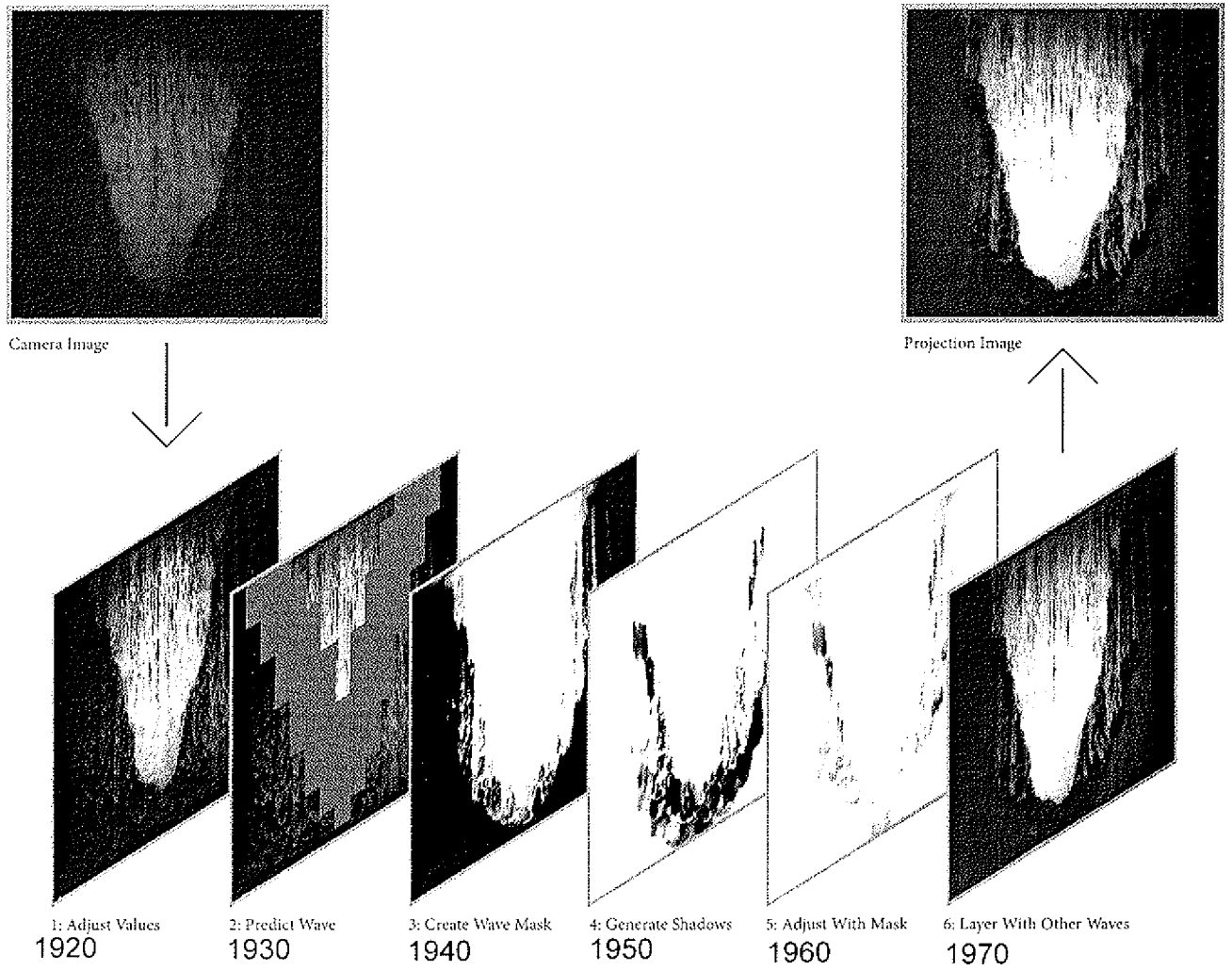


FIGURE 18XXX

Figure 19

Shadow Effect Example Frame Deconstruction 1900



Reversal Effect Example Timeline 1990

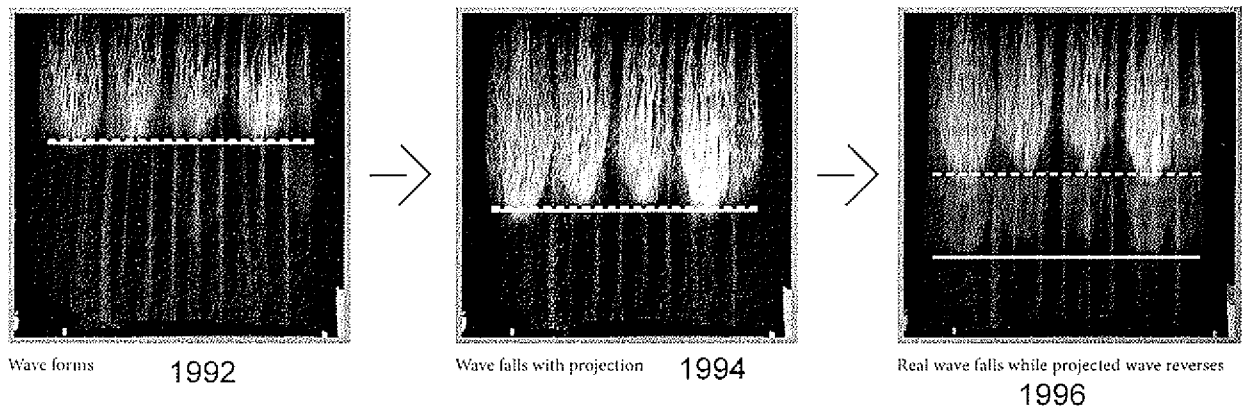
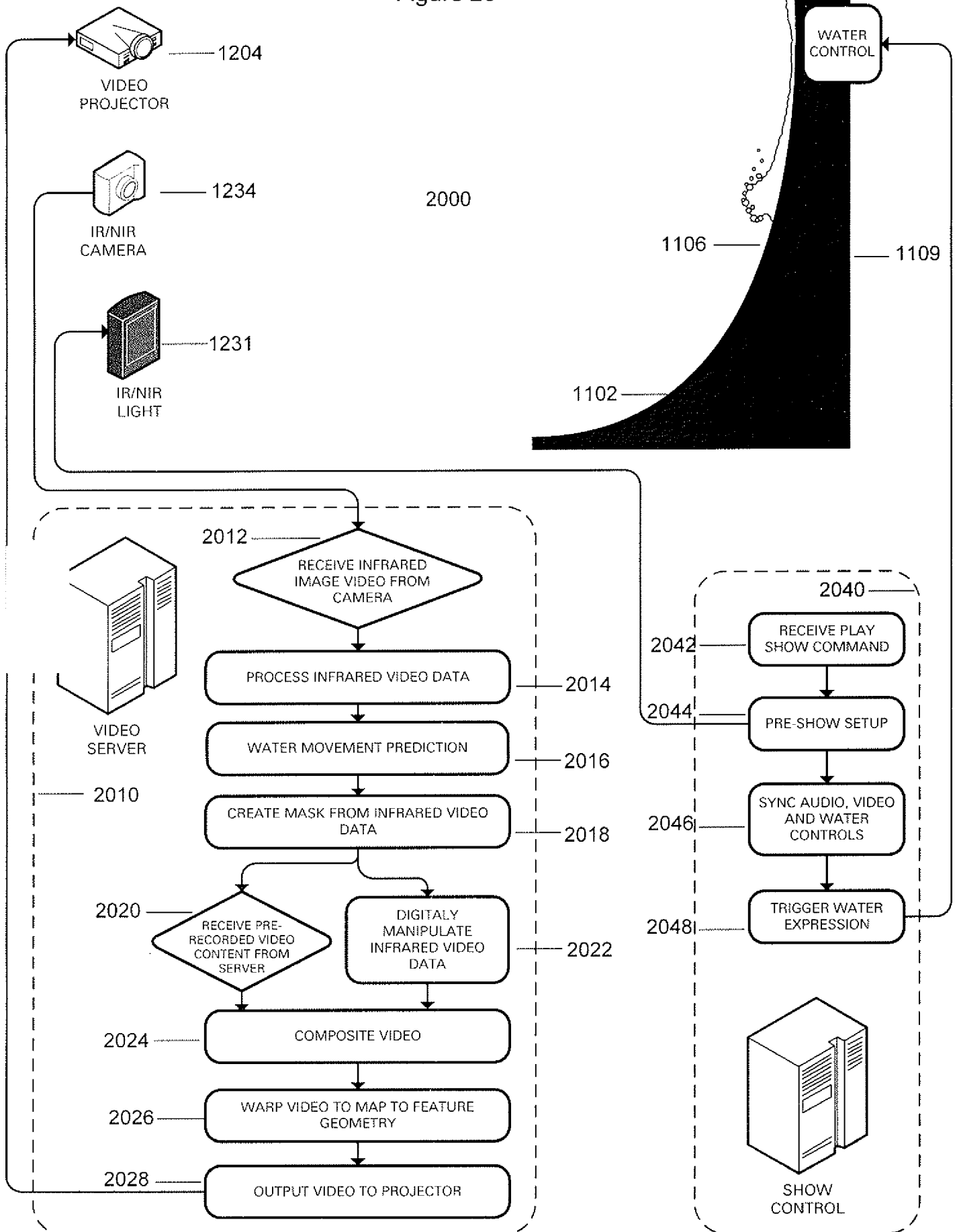


Figure 20

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A. CLASSIFICATION OF SUBJECT MATTER**G03B 21/608(2014.01)i, H04N 9/31(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G03B 21/608; B64B 1/50; G03B 15/00; G03B 5/00; G06T 3/40; G06T 7/13; H04N 13/02; H04N 5/232; H04N 5/262; H04N 9/31

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: project, video, droplet, sequence, playback, aliasing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2018-211782 A1 (SONY CORPORATION) 22 November 2018 paragraphs [0024]–[0028], [0075]–[0201]; and claim 1	1–14
A	KR 10-2018-0104825 A (ALLBRIDGE CO., LTD.) 27 September 2018 paragraphs [0021]–[0027]; claim 1; and figure 3	1–14
A	US 2014-0063279 A1 (PANASONIC CORPORATION) 06 March 2014 paragraphs [0026]–[0042]; claim 1; and figure 1	1–14
A	US 2017-0293998 A1 (SAMSUNG ELECTRONICS CO., LTD.) 12 October 2017 paragraphs [0061]–[0066]; claim 1; and figure 4	1–14
A	US 2018-0124329 A1 (AXIS AB.) 03 May 2018 paragraphs [0020]–[0028]; claim 1; and figure 1	1–14



Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

14 July 2020 (14.07.2020)

Date of mailing of the international search report

14 July 2020 (14.07.2020)

Name and mailing address of the ISA/KR

International Application Division

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2020/020538

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