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(54) A WEATHER RESISTANT MICROPHONE ASSEMBLY, AND CAMERA ARRANGEMENT COMPRISING SUCH ASSEMBLY

(57) A weather resistant microphone assembly, comprising a microphone element,
a sound-guiding cavity, with the microphone element arranged at an inner end thereof, and an outer end being covered by a screen, thus providing a distance between the microphone and the screen
a water impermeable membrane arranged in the cavity, between the screen and the microphone element, configured to prevent water having entered through the screen from reaching the microphone element.

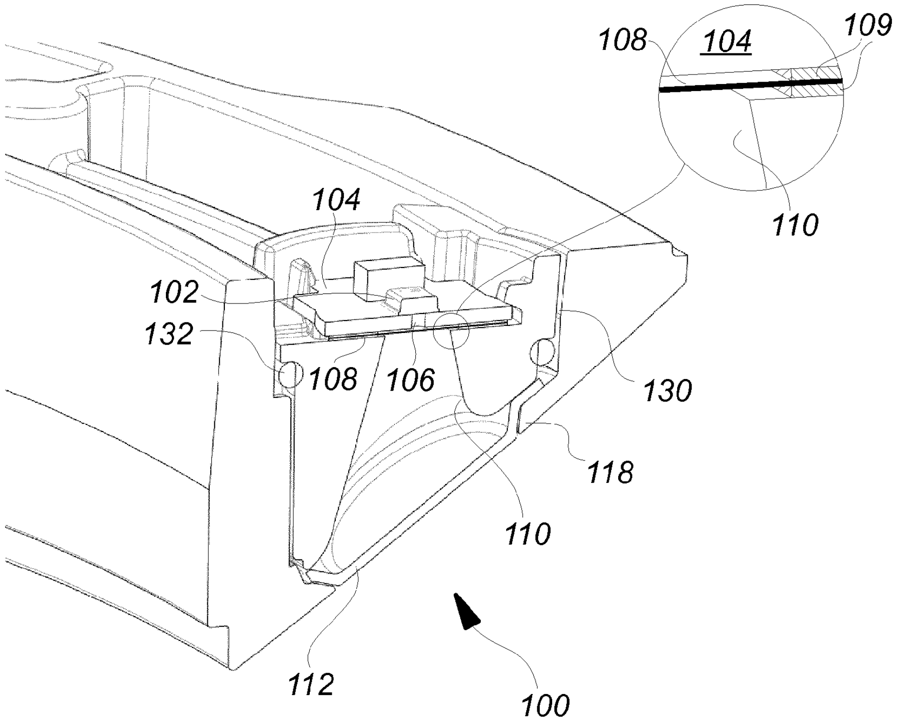

Fig. 2

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Description

Technical field

[0001] The present invention relates to a weather resistant microphone assembly, and in particular to a microphone assembly having increased resistance to the effects of wind and water. The invention also relates to a camera system comprising such microphone assembly.

Background

[0002] Within the field of monitoring cameras use may be made of various microphones. Having a microphone will increase the versatility of a monitoring camera system by providing a further dimension of information. Recording the sound in a monitored scene enables an operator watching the scene, live or in the form of recorded material, to understand the monitored events better. Even in situations where isolated words are not possible to deduce, the sound may be used to draw further conclusions, e.g., if there is an aggressive atmosphere, if there are more events taking place outside the camera view, etc. A further application for microphones is to deduce where a particular sound came from. This is an application that requires a directionality, which either requires a movable, directional, microphone, or a set of microphones that operate in conjunction with each other. Typically, the latter is well suited for automatic systems, such as gunshot detection systems. In a gunshot detection system the microphones will detect a sound that could be interpreted as a gunshot (or explosion, collision, or another sound of that character). Based on the nature of the sound and the time of arrival to each microphone, the system will be able to deduce parameters of the gunshot, in particular where it did come from. Depending on the complexity of the system it could deduce that there was a gunshot, the direction from which it was fired, from where it was fired (i.e. direction and distance), and the direction may also include an elevational angle. Based on this information an operator may be alerted, and if the detection system includes cameras, one or more of the cameras may be homed in towards the source of the detected sound.

[0003] In many installations the gunshot detection system is arranged outdoors, and as such it will be exposed to weather. The effects of wind are detrimental to automatic systems relying on microphones due to the sound generated as wind passes components of the set of microphones. A gust of wind could generate a sound, in each microphone, which an automated evaluation algorithm could interpret as a gunshot, which would result in a false alarm. In this context it may be important to note that the typical gunshot detection system does not discriminate between actual gunshots and sounds of similar character, i.e. sounds having a limited and distinct temporal extension, and often a level that exceeds background noise. Another detrimental weather type is rain. Rain may cause water or moisture to enter a microphone assembly, which may destroy components as such, but which may also form a mechanical obstruction to the progression of a sound wave through the system. The ideal system should consequently have this tolerance to weather, while still not affecting the quality of the sound in terms of the parameters used for detection of a loud noise with this distinct character.

[0004] When microphones are arranged on or in relation to a monitoring camera there may thus be a conflict of interest, since each microphone assembly should be well protected, while the camera (or every camera if it is a system of cameras) will need a field of view being as unobstructed as possible. Since the camera field of view has a high priority, any microphones will have to be adapted for the installation, while still having a performance enabling that they may be purposely used.

[0005] The present invention aims at providing improvements in this area, through the provision of a weather resistant microphone assembly. Gunshot detectors may be a suitable use case for such a microphone assembly, but it may equally well be used in any installation where it would be exposed to the effects of weather, such as a regular monitoring camera arranged outdoors. A further criterion in such an installation is that it should be reasonably well protected towards mechanical impacts, since it may be exposed to that too.

Summary of the invention

[0006] One object of the present invention is to provide a new and improved solution for microphone assemblies located in areas subjected to the effects of weather. That object is achieved in full or at least in part, by a weather resistant microphone assembly, comprising a microphone element, a sound-guiding cavity, with the microphone element arranged at an inner end thereof and an outer end being covered by a screen, the cavity thus providing a distance between the microphone element and the screen, the assembly further comprising a water impermeable membrane arranged in the cavity, between the screen and the microphone element, configured to prevent water having entered through the screen from reaching the microphone element.

[0007] The present construction will offer a multistep weather protection, where the adverse effects of wind is handled by the screen, which also provides a first barrier against ingress of water. The sound guiding cavity will then act as another obstacle, and by its mere presence and that it provides a distance between the screen and the microphone element. Closer to the microphone element the water impermeable membrane will ensure that no water reaches the microphone element or any electronics. Each element (screen, membrane, cavity) may be optimized in achieving its purpose while it still transfers sound without distortion. The sound level should be affected as little as possible, but more importantly for one of the intended uses, the temporal extension of the sound wave should not be affected to the extent that it seems to be affected by prior art solutions.

[0008] In one or more embodiments a plate is arranged at the inner end of the cavity, wherein a structure defining the cavity is attached to the plate, and wherein the microphone is arranged on a remote side of the plate, the plate having an opening extending from the cavity to the microphone, and in still other embodiments the plate is a printed circuit board. The plate (or the PCB, or the flexible PCB, etc) will act as yet another physical barrier in the assembly, and the opening in the plate will help guiding the sound to the microphone element.

[0009] In at least one embodiment the membrane is arranged between the structure defining the cavity and the plate, with a clearance between the membrane and the plate. Positioning the membrane close to the microphone element (and far from the screen) may be an advantageous approach. Also, by allowing the membrane to perform an oscillating motion without interacting with the plate, due to the clearance, results in a good transfer of sound without additional generation of noise caused by a direct physical contact. This has proven to be advantageous compared to arranging the membrane in direct contact with adjacent components in a way that hampers its movability.

[0010] To ensure maximal motion the membrane is preferably fastened along a peripheral area thereof, leaving a free central portion, and wherein the free central portion is dimensioned so as to promote undistorted transfer of sound in a predetermined frequency interval. Dimensioning the central portion may include accounting for structural parameters (stiffness, density, etc) of the membrane, as well as the physical dimensions, e.g., the diameter.

[0011] In an effort to minimize the effect of wind the screen is formed from a structure having multiple through-holes, wherein the size of the through-holes is preferably smaller than a thickness of the structure. This enables to obtain a rigid structure (comparably rigid) while still having suitable properties for transfer of sound and providing a first barrier against water and dissipating energy from wind with minimal generation of noise.

[0012] To further improve the mechanical properties of the screen, it may have a double curvature along a peripheral area thereof, e.g., by having the outer portion bent downwards or upwards in an outer area along the entire circumference, or it may have a double curvature along a major portion of its total area, e.g. being bulged inwards or outwards. Once deformed to a double curvature the screen will be less prone to bend further. This may increase the direct mechanical strength, and it may also reduce the risk for the screen to start to vibrate, which could result in an additional source of noise.

[0013] In one or more embodiments the screen may be formed from a wire mesh, and in a preferred embodiment the screen is formed from an inner screen with a first mesh size, and an outer screen with a second mesh size. The use of a wire mesh is a very convenient way of obtaining a durable screen with suitable acoustic properties. The use of a double screen may result in several properties being beneficial for the performance of the screen. Some of these properties will be discussed further in the detailed description.

[0014] In one or more embodiments the second mesh size is larger than the first mesh size. While the opposite relationship is also possible, said order is believed to result in a sequential reduction in the effects of wind. Having different sizes of the meshes also has a benefit in that the size of a resulting effective open cross section is predictable while still not requiring delicate alignment during assembly (production). Compare to a situation where the mesh size is equal in both the inner and the outer screen, in which case the effective open cross section will be highly dependent on a positional shift between the screens.

[0015] In the case of metal screens it is preferred that the inner screen is attached to the outer screen by means of sintering. Still, other means of attachment are also possible, such as adhesive, welding, folding, or clamping. Also, it is preferred that a mean mesh size for the screen is smaller than a mean mesh size for the inner and outer screen, respectively. This is a beneficial effect from using a double screen structure, that the mean mesh size, or effective open cross section, may be reduced as compared to the smaller mesh size of the screens used. Further screens may be added.

[0016] According to another aspect of the present invention there is provided a monitoring camera arrangement. The arrangement comprises two or more microphone assemblies according to what has already been described or will be described in the following. The arrangement will further comprise a control unit configured to use information from the microphone assemblies to calculate a direction to a source of incoming sound detected by the microphone assemblies. Utilization of the microphone assembly in this type of arrangement is a highly suitable application for the microphone assembly since it has been designed to maintain properties of an incoming sound in such a way that a waveform is maintained, enabling automatic detection of a distinct loud sound.

[0017] In such an application the screen may be arranged flush with, or extend beyond, an outer surface of a housing of the monitoring camera arrangement. A flush arrangement is believed to reduce the interaction with wind, by protecting it from direct engagement. In an embodiment where the screen extends beyond the surface, it may be more exposed to wind, yet it may also be arranged further away from the microphone element which may equalize the effect. It is believed that having the screen lower than the outer surface of the housing may offer a cavity which may interact with the wind in a non-optimal way, such that excessive noise is generated, also the screen will be arranged unnecessarily close to the microphone element. The present invention consequently offers enough versatility to allow for pure design considerations.

[0018] To make full use of the sound detection and in particular the localization of the source of the detected sound, it is preferred that the camera arrangement is configured to provide omnidirectional overview of the camera surroundings.

[0019] A further scope of applicability of the present invention will become apparent from the detailed description given below. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

[0020] Hence, it is to be understood that this invention is not limited to the particular component parts of the device described or steps of the methods described as such device and method may vary. It is also to be understood that the terminology used herein is for purpose of describing particular embodiments only, and is not intended to be limiting. It must be noted that, as used in the specification and the appended claim, the articles "a", "an", "the", and "said" are intended to mean that there are one or more of the elements unless the context clearly dictates otherwise. Thus, for example, a reference to "an object" or "the object" may include several objects, and the like. Furthermore, the word "comprising" does not exclude other elements or steps.

Brief description of the drawings

[0021] The invention will now be described in more detail by way of example and with reference to the accompanying schematic drawings, in which:

Fig. 1 is a sectional sideview of a microphone assembly according to a first embodiment of the present invention, the microphone assembly being located in a camera arrangement.

Fig. 2 is a perspective view, partially in section showing essentially the same assembly as Fig. 1.

Fig. 3 is a sectional sideview of a screen used in a microphone assembly of an embodiment of the present invention.

Fig. 4 is a side view of a camera arrangement comprising several microphone assemblies according to embodiments of the present invention.

Detailed description of embodiments

[0022] Fig. 1 is a sectional view of a microphone assembly 100 in accordance with a first embodiment of the present invention. The assembly 100 has a microphone element 102 (will be referred to as "microphone" in the following) arranged on a printed circuit board (PCB) 104.

[0023] There is an opening 106 in the PCB 104 and on the remote side of the opening 106 a membrane 108 is arranged. The membrane 108 is attached to the PCB by means of an adhesive, and it provides a barrier preventing any water from reaching the microphone 102 while allowing sound waves to reach the microphone 102 via the opening 106. Importantly, the membrane 108 should have properties such that it does not obstruct transfer of sound, at least not of sound with the particular characteristics for which the microphone assembly is intended to pick up. During the work leading up to the present invention it was discovered that a performance of the microphone assembly could be hampered by a poor choice of membrane. There were membranes that would smear out the sound signal in time, such that a distinct peak of sound would be transformed to several smaller and less defined peaks. This may completely disable an automatic detection, and either force an operator to miss a lot of detections or to accept a significant load of false detections, neither alternative being an attractive one. As an example, the membrane of the present embodiment is a PTFE mesh combined with a PET backing material (for rigidity). The thickness is about 48 micrometers, and the construction will be both hydrophobic and oleophobic, while having a 1 dB loss at 1 kHz. The skilled person will realize that there are many variations that may be made in respect of the material of the membrane, since it is the performance that will matter rather than the actual composition.

[0024] A sound-guiding cavity 110 extends from the PCB 104, and the membrane 108 is clamped between the PCB 104 and the sound-guiding cavity 110. In other embodiments, the membrane may have an outer perimeter matching the inner perimeter of the cavity, such that it is not clamped, and in still other embodiments it may be even smaller. The sound-guiding cavity 110 opens up or flares with increasing distance from the PCB 104, and the far open end is covered by a protective screen 112. The protective screen 112 will be described in greater detail further on, but its general purpose is to protect the assembly from water and the potentially adverse effects of wind, while still allowing sound waves to pass essentially unaffected. The last item is very important, since without this requirement the object would be readily accomplished. In particular, the screen 112 has a very important role in preventing wind to interact directly with the microphone, since such interaction would hamper any possibilities to perform meaningful measurements due to strong distortions. There are many possible solutions for the material and design of the screen, which will prevent wind/microphone interaction. It has, however, proven to be difficult to fulfil the criteria while still maintaining the qualitative parameters of incoming sound in such a way that detection of a particular sound is enabled. Wind as such is merely movement of air, and that is no problem. The potential issues arise when the wind interacts with the screen, or whatever protective arrangement there is in front of the microphone, since this interaction may generate turbulence. The turbulence may in turn generate a noise having a volume and frequency interfering with the sound to be detected, or that simply generates an abundance of noise that causes an automatic detection system to generate false alarms at an unacceptable rate. Also, the protective screen should offer some protection against mechanical impact, which is already accomplished to some degree thanks to the relatively small dimensions of the open end. The sound-guiding cavity 110 also has the purpose of distancing the microphone 102 from any noise generated at the screen 112. The sound of interest will have essentially the same sound level at the location of the screen and at the location of the microphone anyway, since the difference in distance between a source of the sound and the screen and the microphone, respectively, will be negligible, while the sound level for sound generated at the screen will fade off rapidly with distance.

[0025] The microphone assembly 100 as shown in Fig. 1 is a cut-out view from where it is arranged in a monitoring camera arrangement (to be described later), and in this arrangement it is beneficial that the protective screen is arranged flush with an outer surface of the monitoring camera arrangement. This is partly for aesthetical reasons, partly for the microphone assembly to be as protected as possible but mainly to minimize the generation of turbulence as wind interacts with the screen. There are consequently advantages with using the suggested layout, while in other embodiments the screen may extend further outside of the outer surface or be located inside of the same without departing from the gist of the present invention as defined by the claims. If the screen extends beyond the outer surface it may be more exposed to wind, and more turbulence and therefore noise may be generated, but at the same time, given the same geometrical constraints inside the microphone assembly, it may be located further away from the microphone which would reduce the effect of such noise.

[0026] Fig. 2 illustrates the same sectional view as Fig. 1, yet with a slight perspective so as to give a better understanding of the embodiment. The same numbering applies, and numbered components not yet referred to will be used at a later stage in the present description.

[0027] Returning now to the individual components in some more detail. The microphone 102 is preferably a microphone with a high acoustic overload point (AOP), being well-suited for noisy environments and high acoustic loads. In this specific embodiment an analogue MEMS microphone is used, since it has a suitable size and performance. Other options are available.

[0028] The PCB 104 is designed to transform the sound detected by the microphone to a signal that can be processed. The PCB may comprise some signal processing capabilities, and it may forward results having been processed in a varying level of detail (ranging from not at all to fully) to further processing in a more complex control unit (e.g. a sound card). This may be the case in particular when there are multiple microphones that operate in conjunction with each other.

[0029] The signal processing that could be performed on the microphone PCB or at another location includes processing a sound being detected by the microphone as a function of time, determining the sound level at least in relative measures, comparing it with a threshold sound level, deducing a gradient of the sound level and comparing the time of arrival of sound pressure emanating from the same source but being recorded by other microphones. We will return to this when describing a relevant embodiment.

[0030] The opening 106 in the PCB is dimensioned to allow sound to pass. An upper limit for the size will be more or less given by the dimensions of the microphone which is attached so as to cover one end of the opening. Other parameters that could affect it would be the volume of neighboring volumes. For the present embodiment a suitable diameter was proven to be about 0.5-1 mm, with 0.8 mm as the current diameter. Within reasonable boundaries the exact diameter is not that critical. It not be so small so that it in some way quench the sound propagation, and there is little point in having it larger than the actual microphone, rather the opposite, since all sound passing the opening should be detected by the microphone. The reason being collection efficiency, but also in order to avoid that sound escapes the intended microphone and pollutes the sound environment for other potential microphones included in the arrangement.

[0031] A main purpose of the membrane 108 is to be a barrier against water ingress, but since it should not interfere with the progression of sound it will be very thin and resilient, and it should be allowed to vibrate or oscillate. Since it must be configured to transfer sound (or relevant properties) without significant losses in sound level or destruction of the temporal profile, it will be a component to account for in an acoustic meaning. The membrane should be allowed to vibrate without interaction with the microphone (or the PCB or plate to which the microphone is arranged) by means of direct physical contact, since such contact could interfere with transfer efficiency as well as generating a direct physical interference.

[0032] In the present embodiment the membrane is fastened to both the PCB and the structure defining the sound-guiding cavity by means of an adhesive, schematically illustrated at 109, in the magnified detail of Fig. 2. The adhesive will act as fastening means for the membrane 108, yet it will also act as a separator, giving the free portion of the membrane (i.e. the portion not being affected by the adhesive) the ability to vibrate freely, without interacting with neither the PCB 108 nor the structure defining the sound-guiding cavity 110. The adhesive will also provide a seal. If another fastening method is used, or if adhesive is only used on one of the sides of the membrane, a gasket, a ledge, or another structural separator may be used on one or both sides of the membrane. In still other embodiments a clearance is only arranged between the PCB and the membrane, not between the membrane and any structure on the other side of it (in the present embodiment, the structure defining the sound-guiding cavity). In the magnified detail view of Fig. 2 there is an adhesive free distance inside of the edge of the sound-guiding cavity. This distance is not an essential feature of the present invention.

[0033] For the present embodiment the properties of the membrane 108 and its suspension are optimized for supporting progression of sound with a frequency of about 1-4 kHz without distorting its waveform (i.e. the temporal behavior of the signal).

[0034] Turning now to the sound-guiding cavity 110, it presents an increasing cross section with distance from the PCB. The cross section of the cavity 110 closest to the PCB is dimensioned to enable a suitable design of the membrane 108. The length of the cavity is configured to be fractions of the wavelength of the sound of interest, at least less than a half or a quarter of a wavelength, to prevent resonance peaks in the frequency interval of interest or other interferences. Given a frequency of 4 kHz as an upper limit results in a maximum length (half a wavelength) of about 4.3 cm, or about 2 cm (for a quarter of a wavelength). For the present embodiment the distance is less than 1 cm which is well distanced from the theoretical maximum length. Depending on a specific use case the distance may also be different, obviously, and also for the exact same conditions as the present embodiment it may differ from 1 cm, the estimation given is not a sweet spot, merely a suggestive value. As mentioned before, the length of the sound-guiding cavity, or the distance between the microphone and the screen, will have a direct impact in how well noise generated at the screen is transferred from the screen to the microphone. This may also be a design feature to account for when designing the microphone assembly for a particular use case. The sound-guiding cavity may preferably be made from plastic or metal, or a composite material. One quite important criterium is that the material (or the construction made from the material) should offer an acoustic seal. The function of providing an acoustic seal is an important feature for the product as such. The aim is to ensure that any detected sound comes from the environment and not from within the microphone assembly itself. When the microphone assembly is arranged in association with a camera arrangement this becomes even more important, since the camera arrangement itself may be a source of sound. There are camera control motors for pan and tilt, zoom mechanisms, possibly cooling/heating fans, etc. all providing sources of noise very close to the microphone, and as wind interacts with the camera arrangement further noise may be induced.

[0035] The protective screen 112 covering the far end opening of the cavity, remote from the PCB, may have any of several designs. The use of a screen, meaning a solid structure with a number of through-holes, generally arranged in a repetitive arrangement, has proven suitable for the purposes of the present invention. The through-holes will allow a sound wave to pass without causing a distortion, while still preventing water from passing, at least to some extent. At the same time, and equally important, energy from wind passing the screen will be efficiently taken care of, without generating excessive noise close to the microphone. There are several options for fulfilling these two criteria; a fine metal or composite mesh could be used, a laser etched plate, plastic screens, moulded screens of plastic or metal etc. For the purposes of the present invention, however, it has been discovered that a dual layer screen is particularly well suited. This dual layer screen comprises an outer screen 114, meant to face the environment outside of the microphone assembly, and an inner screen 116, meant to face towards the interior of the cavity. Sintering is the preferred process for forming a single screen from the inner screen and the outer screen.

[0036] A sectional view of the screen 112, comprising the inner screen 116 and the outer screen 114, is shown in Fig. 3 not illustrating the detailed structure of each screen. The inner and the outer screen may be attached to each other in other ways as well, e.g. with any suitable means of mutual attachment may be used, including, welding, soldering, gluing, or even clamping. Attachment means that would affect the openings through the resulting screen are preferably applied along peripheral edges of the screen, so as not to interfere with the transfer of sound. When clamping is used, the perimeter of the screen may be clamped between edges of the cavity and an outer frame 118 (see Fig. 1).

[0037] In the present embodiment the inner screen is sintered together with the outer screen, through application of heat and pressure. The thus formed screen gets several beneficial purposes in relation to the present purpose. First of all, the sandwiched structure will be rugged and comparably rigid. As will be mentioned in the details, the inner screen has a mesh size that differs from the outer screen. This could further increase the rigidness of the resulting screen. Also, looking at a resulting cross section of an individual opening through the screen, or the mean size of such cross section, it will be smaller than the cross section of the openings of both the outer screen and the inner screen, which also is a beneficial effect for repelling water, or at least preventing it from passing through the screen. A screen of the above type is readily produced from off-the shelf components (referring to the inner and the outer screen respectively), still the properties of the finalized product, and the finalized product itself (the resulting compound screen) is better than what is available. The screen will have an increased thickness as compared to if a single screen with the corresponding resulting opening cross section were to be used. This both adds to stability and to the difficulty for water to pass.

[0038] Moving to the design of the screen, it may have a double curvature, at least along its perimeter, meaning that it will be bent in more than one rectilinear direction. This is mainly for constructional reasons, but it could also add to the rigidity of the screen. The part of the screen that is visible in use may also have a double curvature, both increasing rigidity and enabling for it to fit with a particular installation (e.g., the outer surface of a camera arrangement in which the microphone assembly is arranged. In the illustrated embodiment the screen does not extend beyond an exterior surface of a product in which the microphone is arranged. The reason for this is that it should be inconspicuous, protected, and that it should minimize the area exposed to any wind. It may be argued that it would be even more protected if it were situated below the same exterior surface, yet such an arrangement could generate turbulence in the indentation above the screen (on the outside, remote from the cavity) which could be detrimental to the performance of the microphone assembly. Also, as has been mentioned before, the screen could extend outside of the surface, e.g., as a bulb-like structure. In other embodiments the screen could bulge inwards or be completely flat.

[0039] In the illustrated embodiment, both the inner screen and the outer screen are made from stainless steel, which has great resistance to moisture and corrosion. The outer screen is the coarser of the two, but the opposite could also be used. Both screens, or the composite screen, will efficiently dissipate the energy in the air, and effect that will increase with the wind speed and thus it will be more pronounced for a faster wind than the slower wind speed generated by the sound waves (not to be confused with the speed of sound, which of course is much faster). The screen will offer a good protection from direct water splashes, and water droplets such as rain, trickling down the edge of the camera arrangement will be guided by the wires and trickle past the screen without entering the sound-guiding cavity.

[0040] For the sake of completeness; in the illustrated embodiment the outer screen is a wire mesh with 50 mesh/inch (square), with a plain weave, and the inner screen is a wire mesh with 40x350 mesh/inch (rectangular), with a reverse Dutch weave. However, the skilled person realizes that there are numerous different mesh-sizes available, and that a particular combination may be suitable for a particular application, as well as that one and the same combination may be suitable for several applications. It is not feasible to account for all possible combinations, at least not within the framework of the present description. The two layers of mesh have been sintered together, so as to form a single structure. It may very well be that the different properties of the two meshes offer a sequential reduction of the effect of wind, but this is yet to be investigated.

[0041] Referring to the water repelling properties, experimental results show that the resulting screen will be fine enough to, when formed to a bowl, hold a quantity of water without letting it through. Water will obviously pass eventually, but just as a note to give the reader a sense of how fine the resulting mesh will be. For completeness a "reverse Dutch woven wire mesh" is characterized in that there is a coarser wire in the weft direction and a finer wire in the warp direction, while "plain weave" is what it says. Again, the present invention should not be limited to any particular mesh size or type of weave.

[0042] Notably, there are multiple different combinations possible for the screen, and the most suitable combination could be affected by the desired performance of the system in which the microphone assembly is arranged, e.g., the type of sound that should be detected, the weather conditions where the system is arranged, the layout of the arrangement in which the microphone assembly is situated, etc. For the present embodiment the suggested combination has been found to have an excellent performance in reducing the effects of the wind, and the water impermeability (not completely impermeable as noted on several occasions) made even better due to the combination of an inner and an outer screen. Even more so, the screen has proven to allow passage of sound without distortion of a temporal waveform, which makes it highly suitable in embodiments designed for detecting distinct sounds, such as gunshots. In the illustrated embodiment individual wires of the inner screen and the outer screen run parallel to each other, yet in other embodiments they may be arranged at an angle, to further increase the rigidity of the resulting screen. In still other embodiments, the screen could be formed from another type of mesh, a non-woven structure, such as a felt or a steel wool construction provided that they provide the sought-for properties.

[0043] Continuing with a possible application for a microphone assembly of the described type, a camera arrangement 120 is illustrated in Fig. 4. The camera arrangement comprises a housing with two transparent protective surfaces 122 and 124, respectively. Inside the surface 122 one or more cameras 126 are arranged. In the present embodiment four fixed view cameras are arranged (three of which are visible in Fig. 4), which together may be used to form a 360-degree view of the surrounding area. A PTZ-camera 128 is arranged inside of the protective surface 124. It is beneficial if the camera arrangement is omnidirectional, such that it can acquire images in all directions. For installations where the camera arrangement is mounted on an exterior wall of a building, full omnidirectionality is not possible (the wall will be in the way), but the goal is to be able to acquire images of any area having free line of sight to the camera arrangement, so this is the definition of "omnidirectional" which is relevant for the present application. In this way as many events as possible where the microphones register something relevant may be imaged. Omnidirectionality may be accomplished by means of a camera having a wide-angle lens, or fisheye lens, by means of a camera having a pan and tilt (and preferably zoom) functionality (a PTZ camera), or by means of several fixed cameras cooperating to cover a large area, in a panoramic view. These different alternatives may obviously be combined. In one version, a camera having a fisheye lens is combined with a PT- or PTZ-camera, such that an overview may be provided while still allowing selection of a smaller field of view using the PTZ-camera. The use of a PTZ-camera may also be combined with an arrangement where several fixed cameras provide the panoramic overview, which is the situation for the arrangement illustrated in Fig. 4.

[0044] Three microphone assemblies 100 of the disclosed type are distributed along an outer area of the camera arrangement, the screen 112 of two of these are shown in Fig. 4. Referring to the setup shown in the embodiment of Fig. 4 the use of three microphone assemblies will enable localization of the source of a sound, both in a horizontal plane (i.e. a pan angle may be deduced) as well as in a vertical plane (i.e. a tilt angle may also be deduced), and this means that the PTZ-camera 128 could be directed straight at such a source. If only two microphones were used, for the same setup, it would only be possible to extract the pan direction. Depending on the place of installation, this may be fully adequate, and embodiments including two, three, four, or more (such as 6, 7, 8 or even more) microphones should be included within the scope of the present invention as defined by the claims. The only component visible from the outside will be the screen 112. However, the sectional view of Fig. 1 and that of Fig. 2 illustrate a portion of a similar though not identical, camera arrangement 120, meaning that the arrangement, and in particular how the microphone assembly 100 is arranged therein, may be explained and understood in some further detail. The component 110 defining the cavity may in fact be a larger component, also serving the purpose of localizing the microphone assembly 100 within a holding recess 130 in the camera arrangement 120. An o-ring 132 is arranged on an outer perimeter of this cavity component, providing a seal between the cavity component (and thus the microphone assembly) and the recess 130. The seal should preferably provide a water seal, but in several cases, it is more important or at least equally important that it provides an acoustic seal. The o-ring 132 is merely one possible means for obtaining this function, and several other options are available. It is convenient that both sealing functions (water and sound) are provided by the same component, but if found appropriate each sealing function could be provided by a separate component. The PCB 104 essentially rests on the cavity component 110, inside a cutout thereof. It could equally well rest on a seal, or another component, if that is found more advantageous for a particular application, though there is a general advantage in minimizing the number of components. Further, the cavity component extends upwards to assist in localizing the microphone assembly in the holding recess. In turn, the holding recess is provided in a component 118 (earlier referred to as "a frame") of the camera arrangement 120, and a sealing gasket 134 is abuttingly arranged in relation to this component 118, so as to provide a sealed off volume in which the microphone assembly 100 is arranged, and thus a housing for the microphone assembly is provided. In an embodiment where the microphone assembly is used as a separate component or in another application, it could comprise a separate housing (not shown), ensuring that water is unable to enter the assembly from any other direction than possibly through the screen 112. The screen 112 provides the only orifice through which water (and sound) may enter. As mentioned before, the screen will be very efficient as far as repelling water is concerned, and any water or moisture that enters the cavity will not get past the membrane. When assembling the camera arrangement 120, the microphone is arranged in the recess, and as the housing of the camera arrangement is tightened to a base plate (not shown), the microphone assembly will be located, secured and sealed off.

[0045] A sound card (not shown), a specifically designed PCB, will continuously acquire an output from each microphone assembly, for the present embodiment it will be an analogue output. The sound card includes a digital sound processor (DSP) having a software specifically dedicated for the purposes of sound source localization. The software is configured to use the outputs from the microphones as an input, and in turn it will provide an output including a direction, a sound level in relation to a mean sound level, for any sounds exceeding a set threshold. The set threshold may be an absolute threshold, or a relative value compared to a mean sound level for the particular situation. The latter is beneficially used for the purposes of avoiding false alarms in the situation that the general sound level around the arrangement is high, which may be caused by a large crowd or wind conditions. The software will need input in relation to how the microphones are positioned, and a reference system of the cameras of the arrangement should be calibrated in relation to a reference system of the sound processing system, so that meaningful results may be generated. An operator may be allowed to tweak thresholds to adapt the arrangement to a particular installation or situation.

[0046] If there is a sound detected by all three microphones that exceeds this set threshold the sound card will send an interrupt to the camera control system, or a control system communicating with the camera control system. The control system will request data causing the interrupt and receive a number of parameters, such as sound level for the event triggering the interrupt, the mean sound level, and in particular parameters relating to the direction from which the sound came. The following sequence of events will vary with the particular equipment of the camera arrangement and connected applications, but for the particular embodiment the following actions will be performed: The PTZ-camera will be instructed to move so that its field of view covers the relevant direction, and it will be instructed to start recording. There are four fixed cameras covering the entire field of view. At least the camera covering the field of view including the direction will be instructed to start recording, and thanks to the use of a video buffer, the recording may start prior to the event of the triggering sound. In an operator interface the view including the direction may be highlighted, and a warning flag may display **"HIGH SOUND DETECTED", "SOUND ALERT"** or whatever is desired, to alert the operator. Furthermore, automatic messages may be sent to alert relevant personnel, which may include personnel that should see the recording promptly and personnel being in the vicinity of the event that may act on it. A shot detection system based on sound only, may generate an alert as the result of an actual shot, but it may also alert for a car backfiring, a trash bin being dropped, etc. More advanced systems may also utilize the input from further sensors, e.g., a radar detecting an incoming projectile, a thermal camera detecting a muzzle flash in the direction of the sound, etc. If not, it will be the job of an operator to evaluate each alert, and the fact that the present invention enables a reduction in false alarms generated by, e.g., wind, will reduce this burden significantly.

[0047] In the illustrated embodiment the microphone assemblies are integrated with the camera arrangement in a direct constructional manner. In other embodiments one or more microphone assemblies may be provided as an auxiliary device which may be connected to the camera arrangement, or to a control system controlling the camera arrangement. A reason for doing this could be to enable retrofitting of the sound detection system, or to be able to increase the distance between microphones beyond the physical constraints of a camera arrangement.

[0048] Several other actions and events may be generated, but the go to action is to provide data enabling overview of the current situation and forensic data for further investigation. Other alternatives than the ones mentioned could be that the quality of the recorded video is increased, e.g., by temporarily enabling a higher bitrate, so that the image resolution and or image frequency (frames per second, fps) is increased for the relevant cameras. Furthermore, a video stream of optimal quality could be stored locally in the camera arrangement or other edge storage to eliminate the need of a high-quality connection in situation of a critical event, which is particularly beneficial if the event as such could affect the connection. In the disclosed embodiment the entire view is highlighted, yet in other embodiments only a portion of a view may be highlighted in order to assist the operator in localizing the source of the sound promptly. The highlighting could be in the form of an overlay, such as a marked-up rectangle, an arrow or other pointer, a deviating color tint (of the relevant area or of areas surrounding the relevant area) etc.

[0049] The person skilled in the art realizes that the present invention by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims.

Claims

1. A weather resistant microphone assembly (100), comprising a microphone element (102),
a sound-guiding cavity (110), with the microphone element (102) arranged at an inner end thereof, and an outer end being covered by a screen (112), thus providing a distance between the microphone element (102) and the screen (112)
a water impermeable membrane (108) arranged in the cavity (110), between the screen (112) and the microphone element (102), configured to prevent water having entered through the screen (112) from reaching the microphone element (102).

2. The weather resistant microphone assembly of any preceding claim, wherein a plate is arranged at the inner end of the cavity, wherein a structure defining the cavity is attached to the plate, and wherein the microphone element is arranged on a remote side of the plate, the plate having an opening extending from the cavity to the microphone element.

3. The weather resistant microphone assembly of claim 2, wherein the plate is a printed circuit board.

4. The weather resistant microphone assembly of claim 2 or claim 3, wherein the membrane is arranged between the structure defining the cavity and the plate, with a clearance between the membrane and the plate.

5. The weather resistant microphone assembly of claim 4, wherein the membrane is fastened along a peripheral area thereof, leaving a free central portion, and wherein the free central portion is dimensioned so as to promote undistorted transfer of sound in a predetermined frequency interval.

6. The weather resistant microphone assembly of any preceding claim, wherein the screen is formed from a structure having multiple through-holes, wherein the size of the through-holes is smaller than a thickness of the structure.

7. The weather resistant microphone assembly of any preceding claim, wherein the screen has a double curvature along a peripheral area thereof, or wherein the screen has a double curvature along a major portion of its total area.

8. The weather resistant microphone assembly of any preceding claim, wherein the screen is formed from a wire mesh.

9. The weather resistant microphone assembly of any preceding claim, wherein the screen is formed from an inner screen with a first mesh size, and an outer screen with a second mesh size.

10. The weather resistant microphone assembly of claim 9, wherein the second mesh size is larger than the first mesh size.

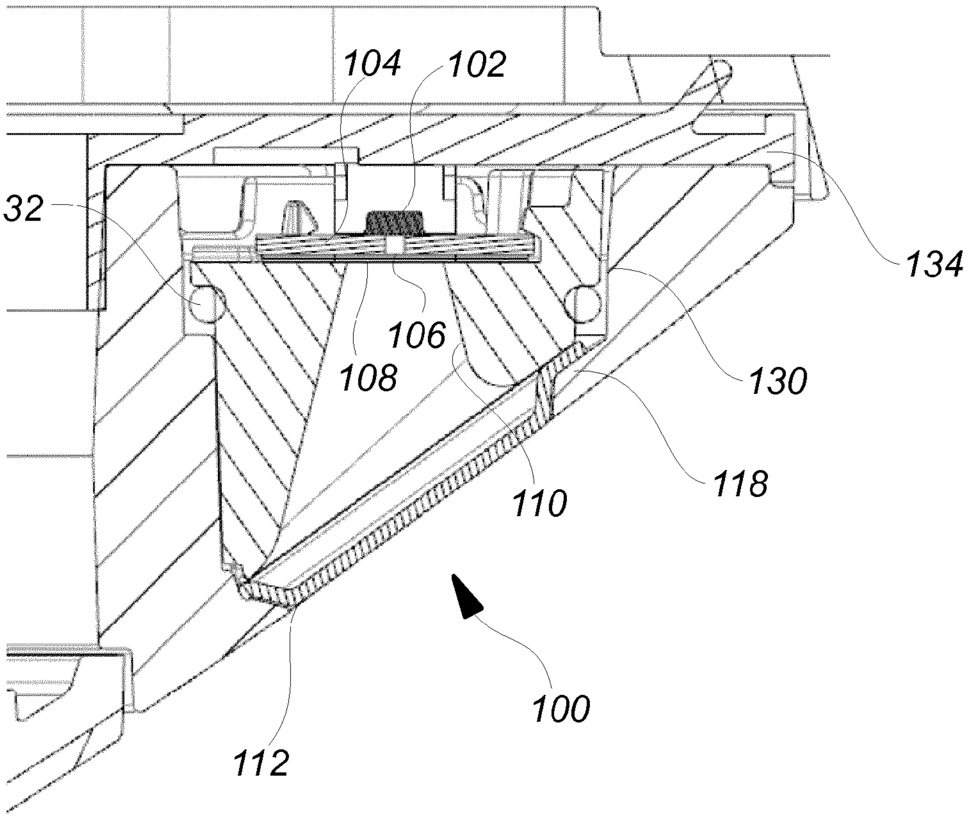
11. The weather resistant microphone assembly of claim 10, wherein the inner screen is attached to the outer screen by means of sintering, adhesive, welding, folding, or clamping, preferably by sintering, and wherein a mean mesh size for the screen is smaller than a mean mesh size for the inner and outer screen, respectively.

12. The weather resistant microphone assembly of any one of claims 9-11, wherein the inner screen and the outer screens are wire meshes.

13. A monitoring camera arrangement comprising two or more microphone assemblies of any preceding claim, said arrangement further comprising a control unit configured to use information from the microphone assemblies to calculate a direction to a source of incoming sound detected by the microphone assemblies.

14. The monitoring camera arrangement of claim 12, wherein the screen is arranged flush with, or extends beyond an outer surface of a housing of the monitoring camera arrangement.

15. The monitoring camera arrangement of claim 11 or claim 12, wherein the camera arrangement is configured to provide omnidirectional overview of the camera surroundings.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112

Fig. 1

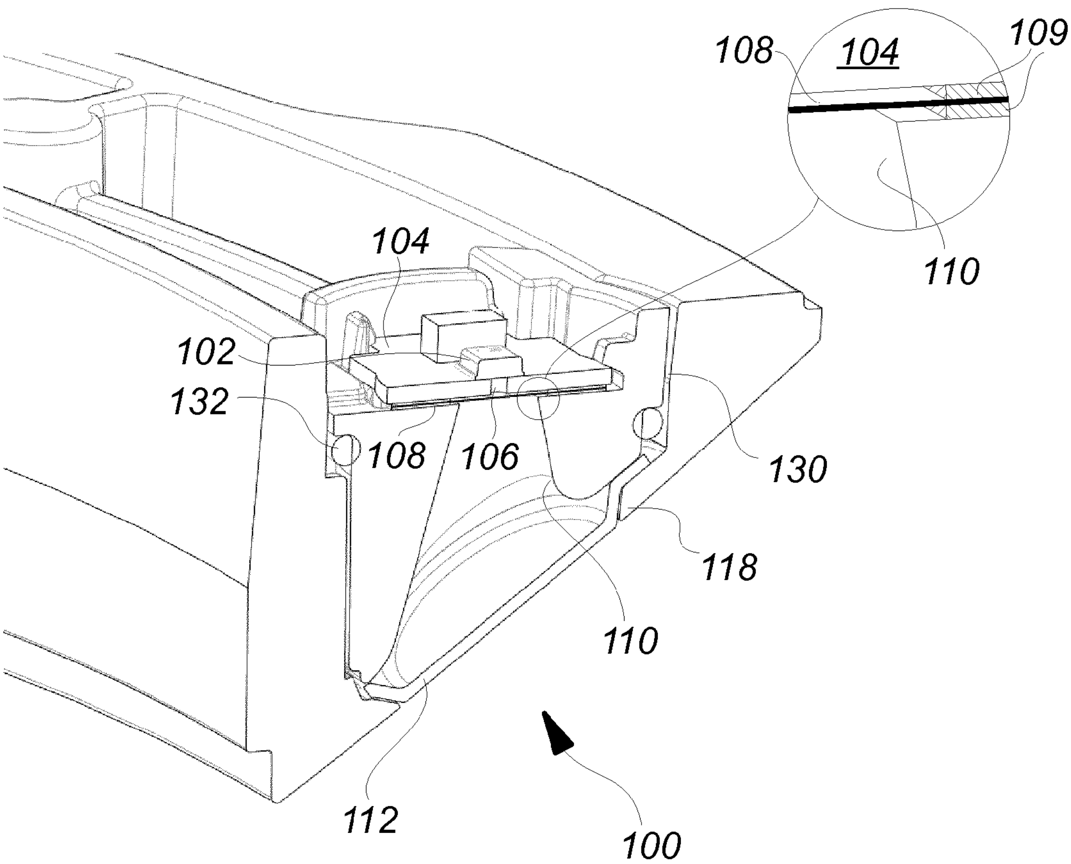
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Fig. 2

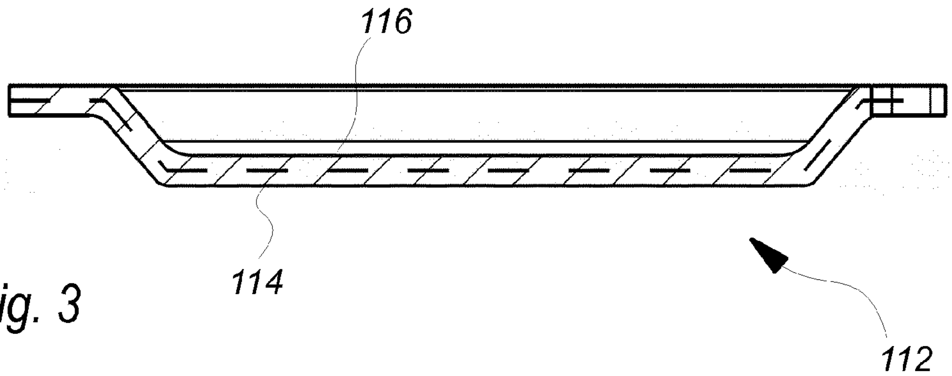

Fig. 3

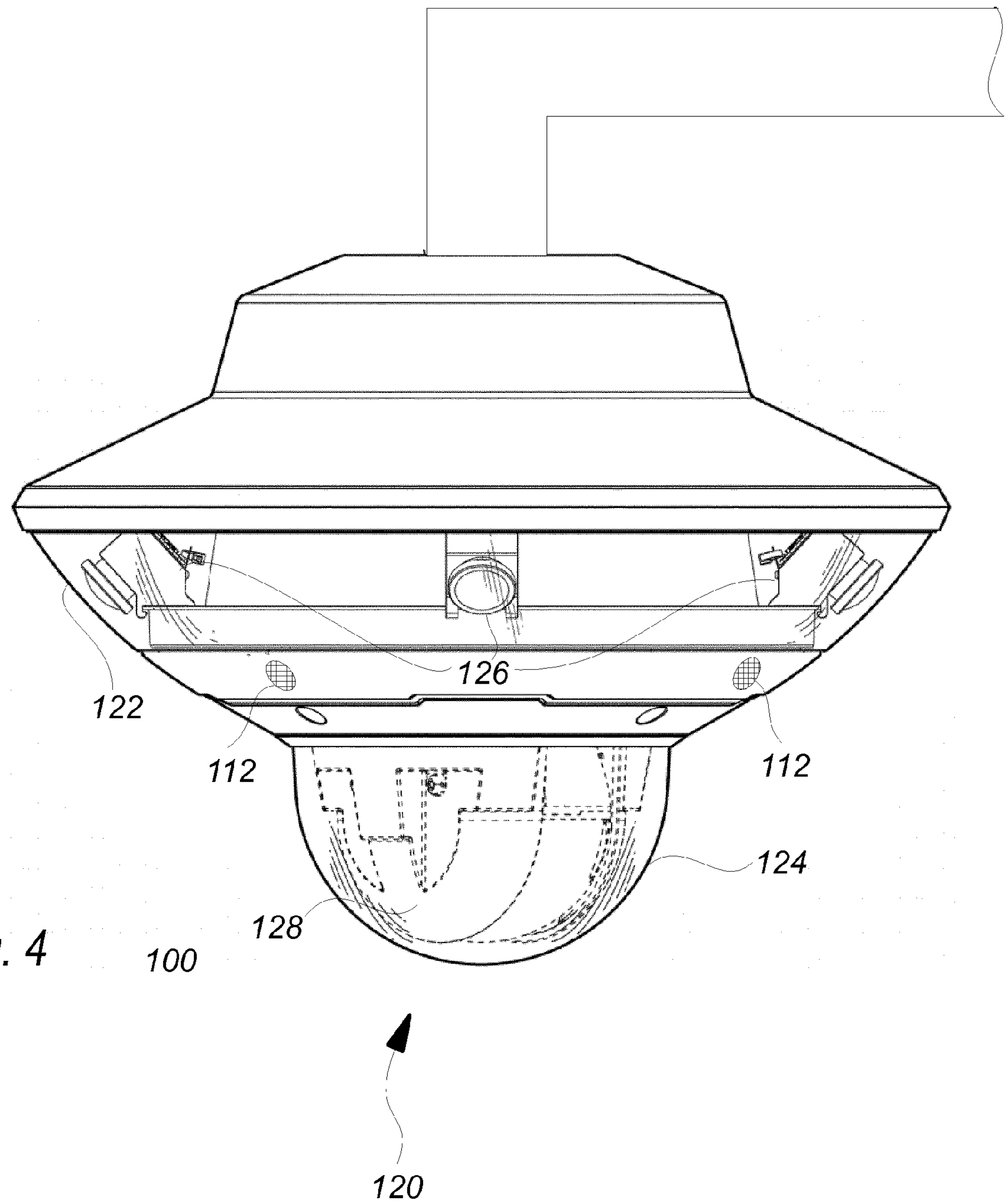

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 19 17 6441

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	11 December 2019	Will, Robert

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 19 17 6441

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 19 17 6441

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-5

   Weather resistant microphone assembly with a plate between cavity and microphone

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2. claims: 6-12

   Weather resistant microphone assembly with a particular screen

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3. claims: 13-15

   Monitoring camera arrangement including weather resistance microphone assemblies

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 19 17 6441

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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