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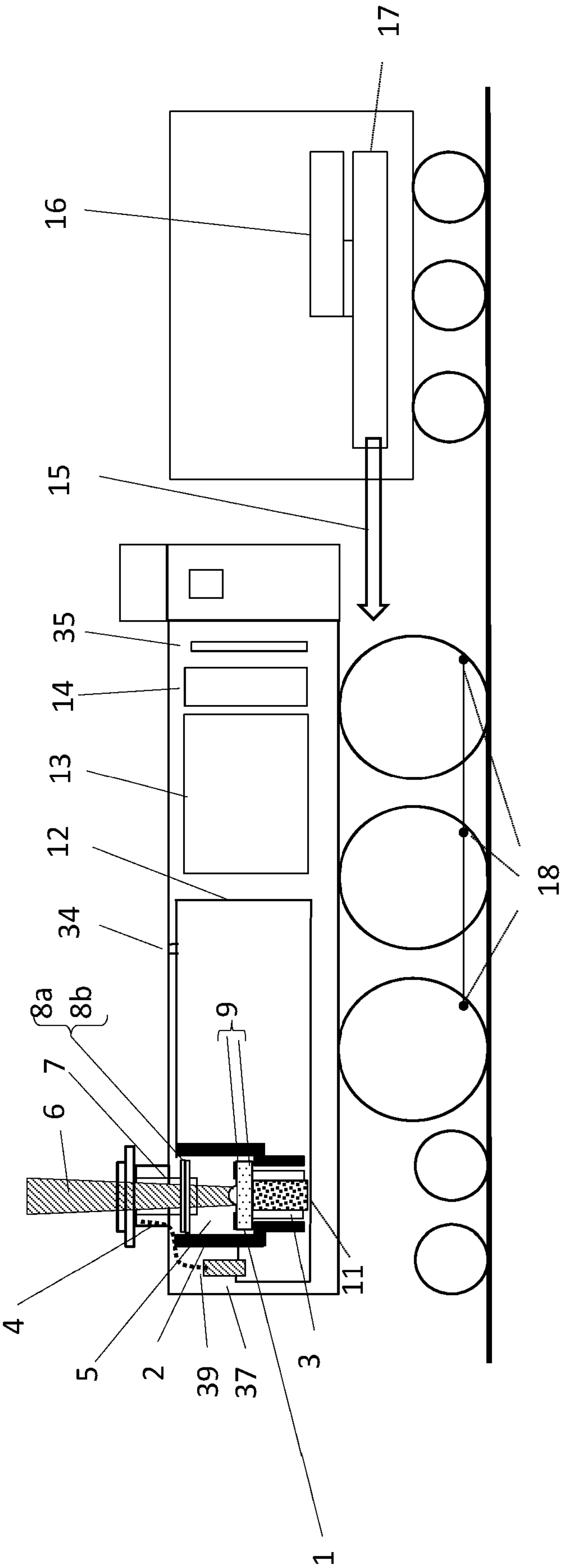

Figure 1

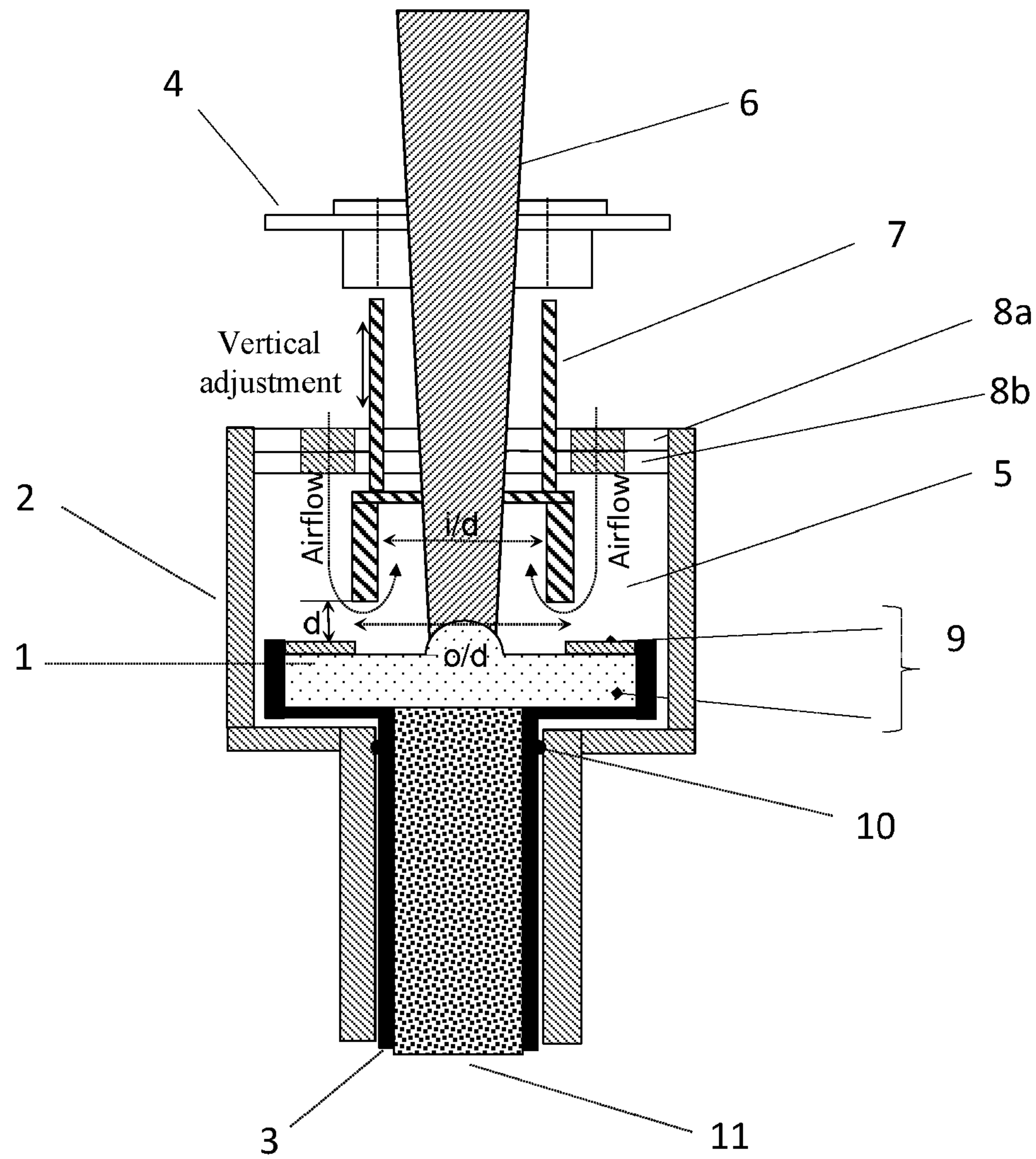

Figure 2

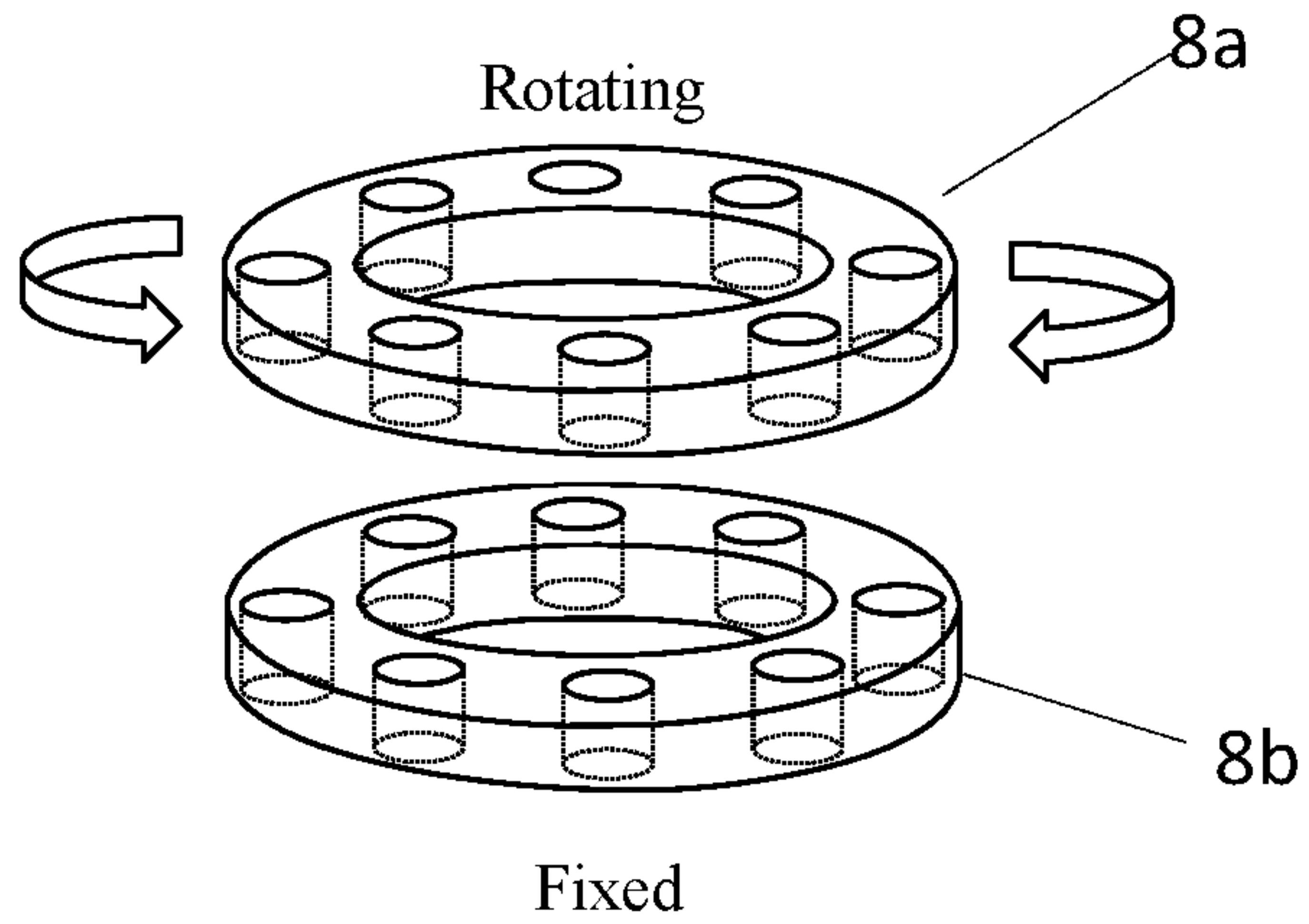

Figure 3

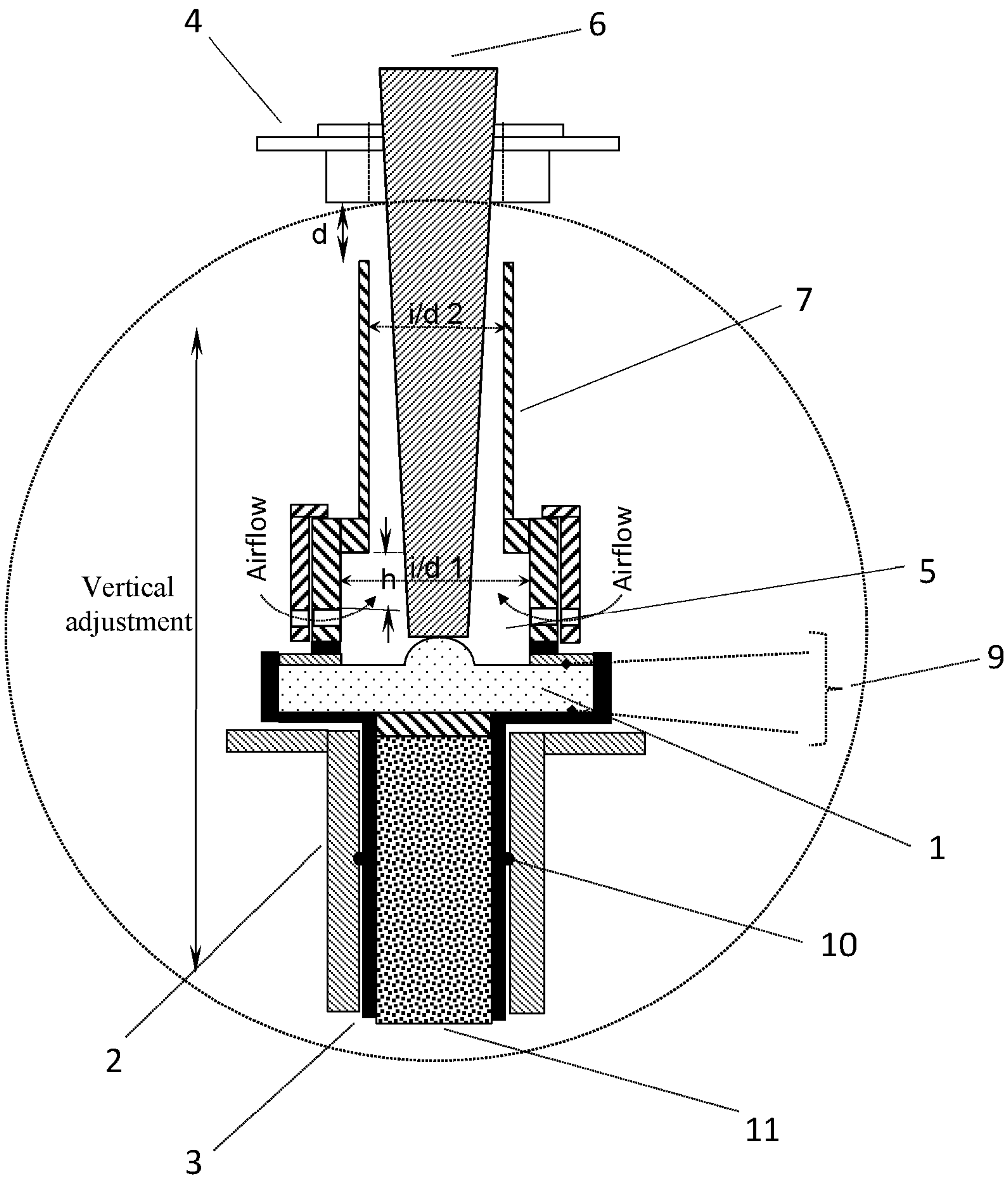

Figure 4

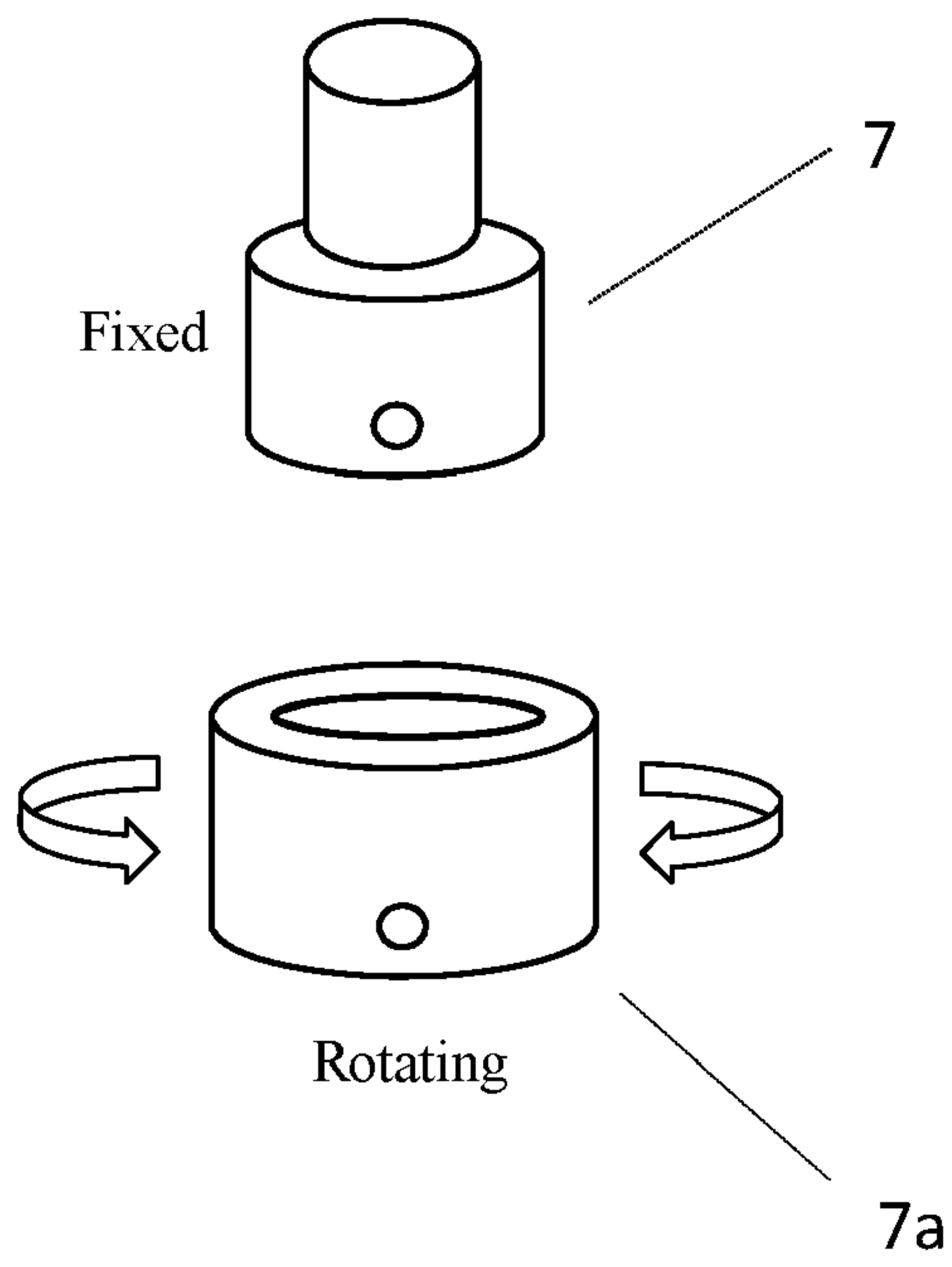

Figure 5

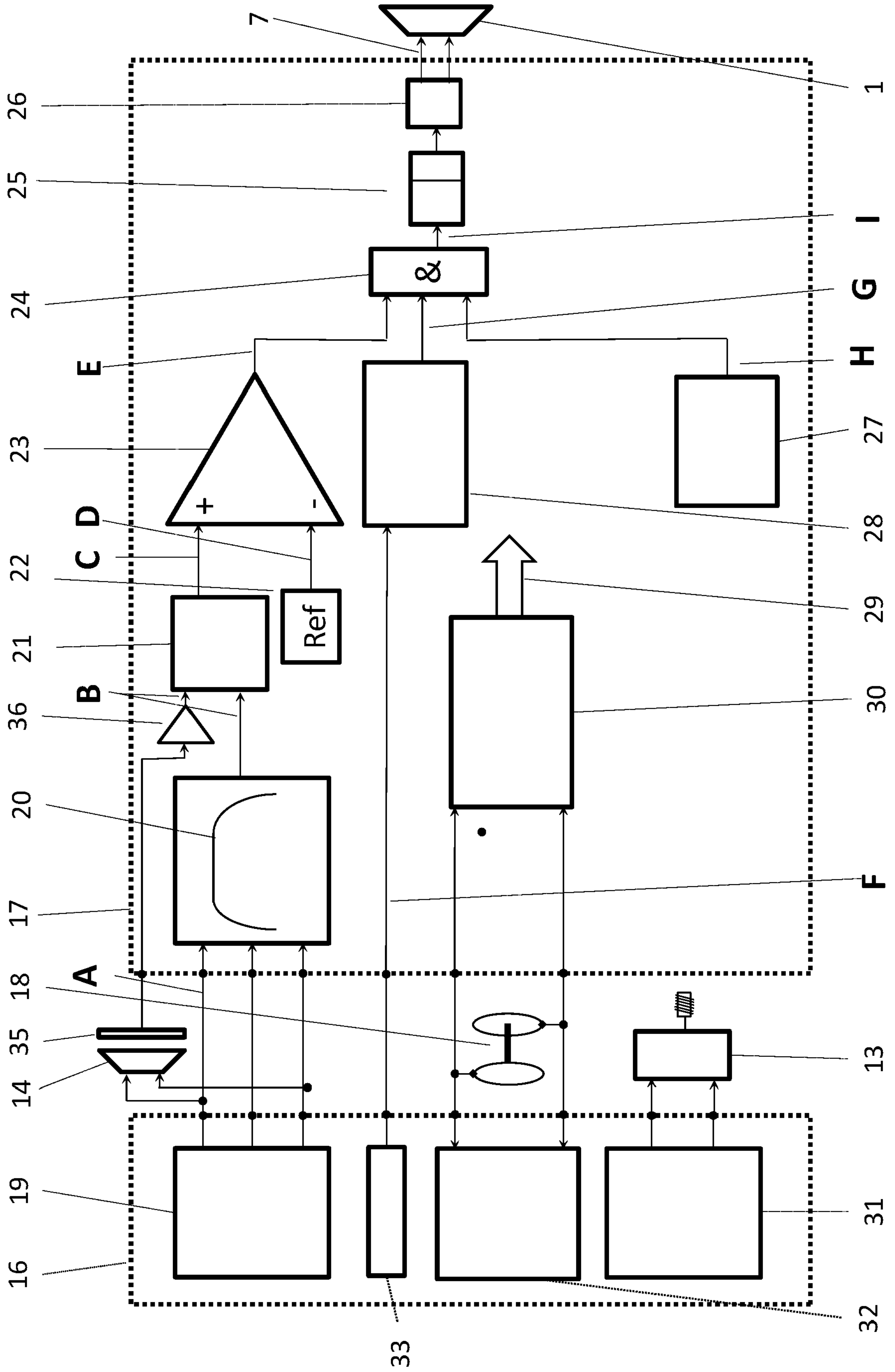
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Figure 6

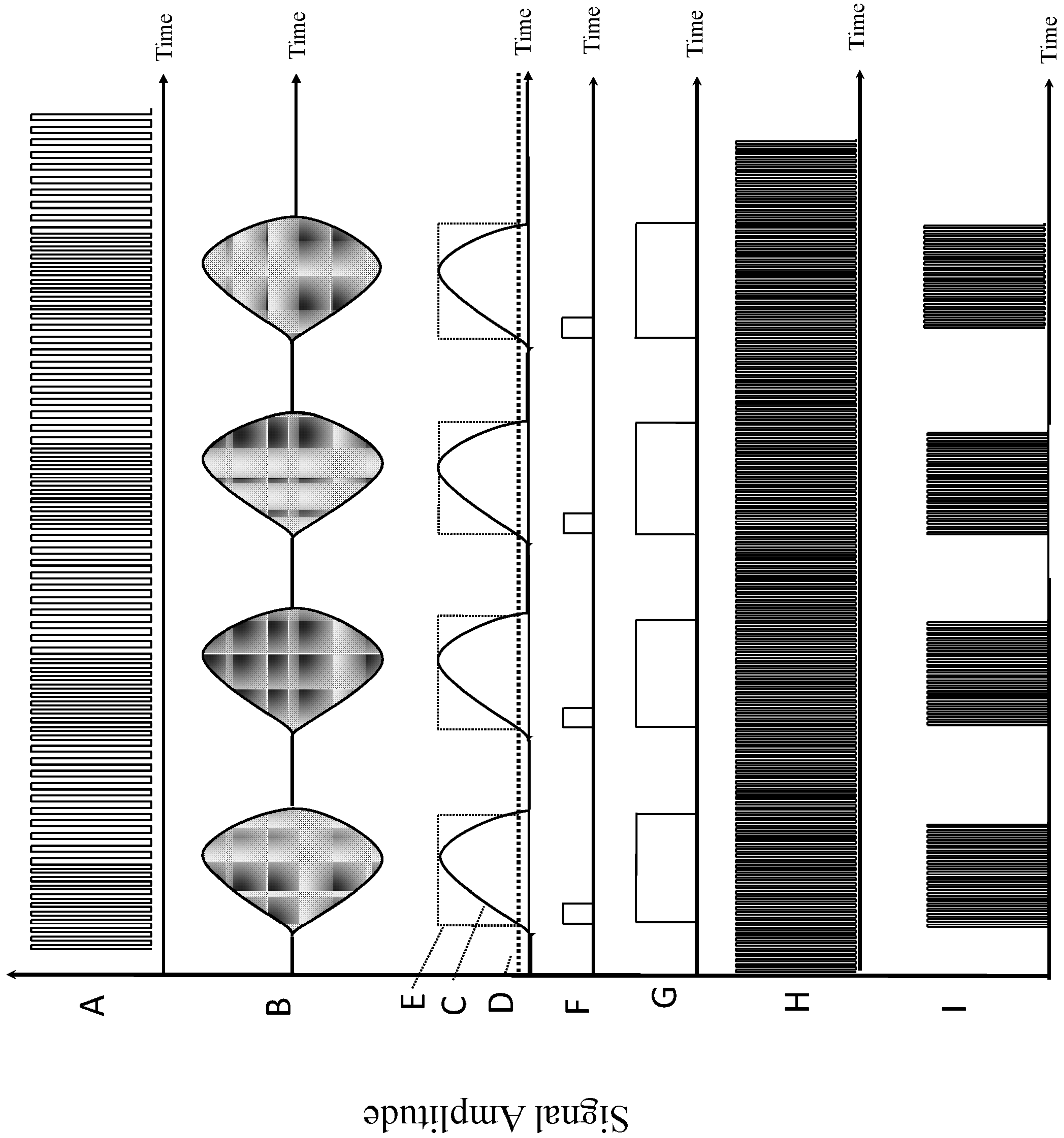
Signal Amplitude
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Figure 7

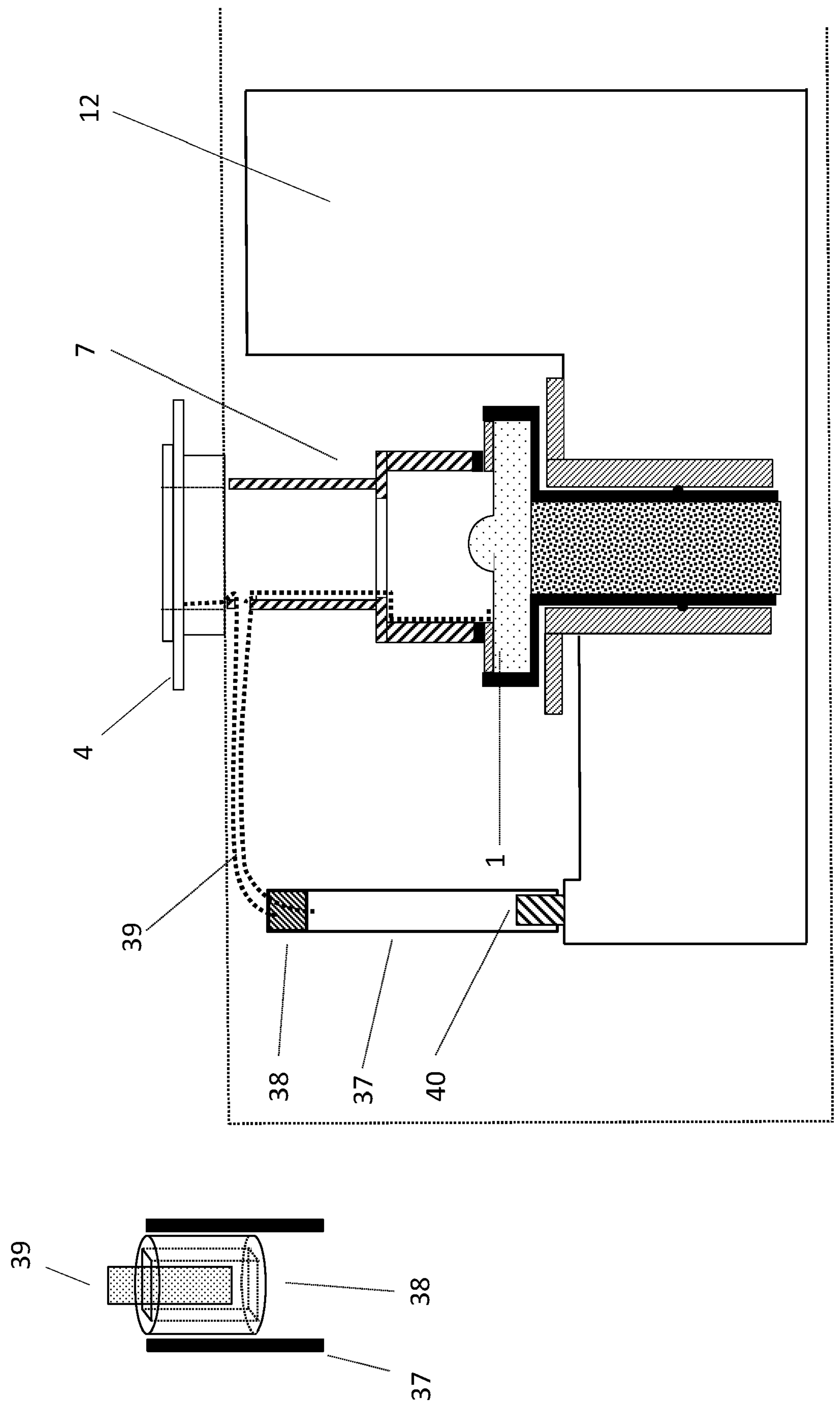

Figure 8

DEVICE FOR GENERATING MIST AND A MODEL TRAIN CONTAINING SUCH A DEVICE

FIELD OF THE INVENTION

The present invention relates to the field of mist generation and to a model train containing a mist generator.

BACKGROUND

There is a desire to make model railway steam or diesel locomotives ever more lifelike. With this in mind, trains that make the sound of steam trains and that generate simulated steam have been devised. The main limitation of all the current systems are the realism of the generated steam/smoke exhaust and a method of accurately synchronising this exhaust and the sound transmitted from an associated audio loudspeaker. Furthermore, such systems face particular challenges with regard to safety and environmental issues associated with generating simulated steam.

The most common method of generating simulated steam/smoke, for a typical model railway locomotive, is to use an electrical heating element to vaporise a low viscosity oil. This method has been in use since Tri-ang Railways first marketed a Smoke Unit fitted to their model locomotives in 1961.

The oil based vaporised smoke is relatively dense and heavy compared to real locomotive exhaust and often drifts downwards causing the track and locomotive to be covered in an oily residue which can be difficult to remove. The running time between refills is also relatively short lived, a typical figure being between 3 -10 minutes. The heat generated by such a smoke generating device has also been known to cause damage to plastic bodied locomotives and so it requires careful fitting and handling.

Another significant disadvantage of the oil based system is that it is prone to destroy itself if the system is operated without vaporising fluid. This situation is a very common occurrence.

Current technology still relies mainly on the use of a continuous electrical current applied to a heating element to vaporise oil and because of this, control over the amount of smoke dispensed is limited.

The relatively recent introduction of Digital Command and Control (DCC) to the world of model railways and their associated locomotives has revolutionised the model railway industry. It is now possible to accurately re-create the actual sound recordings of the individual steam and diesel locomotives. These original recordings are loaded into a DCC sound decoder memory file after which they are replayed through an on-board miniature loudspeaker placed within the model locomotive or its associated tender, the sound changing according to the speed and loading of the locomotive.

The introduction of onboard high quality audio reproduction using a DCC sound decoder is a major advance in the development of highly accurate replicas of full scale railway locomotives.

More recent attempts to improve the realism of locomotive exhaust make use of an electrically driven fan. The limitation with this technique, apart from the use of vaporised oil, is the relatively slow on/off switching time of the fan motor and the limited pressure it can provide to accurately replicate the pressurised exhaust blast of a full scale locomotive.

Therefore, the overall visual effect, whilst favourable in some cases, does still not accurately simulate the exhaust action of a steam or diesel locomotive.

It would be desirable to provide an environmentally safe and more realistic exhaust emission.

SUMMARY

A first aspect provides a mist generating device comprising: a piezoelectric transducer configured to vibrate a plate and atomise liquid contacting said plate to generate said mist; and a signal generator for generating a driving signal for driving said piezoelectric transducer, said signal generator comprising: an input for receiving a signal indicative of a sound made by a steam or diesel locomotive; and circuitry configured to generate a signal synchronised to said received sound signal and to output said signal as said driving signal.

The present invention provides a mist generating device that mechanically converts a liquid into microscopic droplets to create a mist that resembles the steam or smoke exhaust output of a railway locomotive. The device uses a piezoelectric transducer configured to mechanically vibrate a mesh membrane plate and thereby atomise the liquid in contact with the plate. The vibrating plate generates a fine spray of liquid which forms droplets suspended in the air directly above the vibrating plate and gives the appearance of steam or smoke. The liquid supply may be distilled water which provides for an inexpensive, environmentally friendly, low temperature and hence safe mist.

The very rapid responsiveness of such a piezoelectric transducer enables the output of the mist to be accurately synchronised to the sound of a railway locomotive such as the "chuffs" of a steam engine. By using a signal derived from the sound of the locomotive as the driving signal for the transducer, the mist generated by the device can be accurately synchronised to the sound of the locomotive creating an exceptionally realistic audio-visual experience.

In a full-sized steam locomotive the sound output is produced as a direct result of high-pressure steam passing through the chimney. i.e. the sound is generated by and thus, synchronised to the steam. In the present invention the synchronisation is done the other way round, so that the steam is generated in response to the sound signal. The inventor of the present invention recognised that in small-scale model railway locomotive the recorded sounds are readily available from the DCC sound decoder. It therefore follows that the accurate generation of simulated "steam" can be triggered from this already available lifelike sound. Using this technique a more realistic representation of the exhaust and sound emitted from a full-size locomotive has been achieved.

In some embodiments, said received engine sound is a sound of an engine travelling at one of a plurality of different speeds and/or loads.

Modern model railways have digital control and command systems which in conjunction with modern sound decoders and sensors associated with the locomotive allow changes in load and speed to be automatically replicated by the sound decoder in the sound of the locomotive output by such decoder. Using such signals as the trigger signal for the mist generating device allows the mist generation to also reflect the different speeds and loads of a model locomotive.

In this regard modern sound decoders have one or more pre-recorded sound files taken from actual locomotive types, the sound files contain the sound of the locomotive operating at different speeds including when stationary and when under different load conditions. This pre-recorded sound file can be accurately decoded and then replicated to provide a sound that accurately matches the movement of any steam locomotive and as this signal is used for generating the mist it can produce an exhaust for the locomotive that accurately matches the current operating conditions of the locomotive.

Thus, in some embodiments the received locomotive sound is the sound of the locomotive travelling at different speeds and/or at different loads. In this regard, when the locomotive is stationary or under a light load the amplitude of the exhaust is quieter than when starting or accelerating. As the generation of the mist is synchronised to the sound, as the driving signal for the mist generator is produced from the sound signal, this ability to replicate the sound of the engine at different speeds and loads is automatically and faithfully reproduced in the mist generating device providing a mist generating device that replicates the different exhaust outputs of a locomotive at different speeds and under different loads.

In some embodiments, said mist generating device further comprises the sound decoder configured to store locomotive sounds and to generate signals indicative of said locomotive sounds; a loudspeaker configured to receive said signals from said sound decoder and to output said locomotive sounds; wherein said locomotive sound received by said signal generator is a signal indicative of said sound signal output by said loudspeaker.

Although, the mist generating device may simply receive signals from an external sound decoder, in some embodiments the device includes the sound decoder and also the loudspeaker that outputs the sound from the sound decoder.

In some embodiments, said signal indicative of said sound signal comprises a signal received from said sound decoder said signal generator processing said signal to generate said driving signal.

The signal indicative of a sound made by the locomotive may simply be the signal output by the sound decoder, in other embodiments said signal indicative of said sound signal comprises a signal generated by acoustically detecting an output of said loudspeaker. In this regard, the signal from an acoustic detector, also known as a hydrophone, may be amplified and then passed to the signal conditioning circuitry for driving the piezoelectric transducer.

In some embodiments, said circuitry of said signal generator comprises at least one of an electrical filter and signal conditioning circuitry configured to generate said driving signal from peaks in said sound output from said sound decoder indicative of a length and amplitude of a chuff.

When the signal indicative of the sound signal is received at the mist generating device it may be processed to form a suitable driving signal for the piezoelectric device. In this regard, where the signal is received from the output of the decoder it may pass through an electrical filter which may have a band-pass or a low-pass filter response characteristic, such a filter extracts the acoustic wave information from the switching frequency at the output of the decoder audio power amplifier. This signal is then ~~be~~ conditioned by circuitry to provide a signal indicative of the length and amplitude of the chuff.

Where the signal is taken from the loudspeaker having first been detected by an acoustic detector then there will be no requirement for the initial electrical filter as the need to remove the switching frequency generated by the sound decoder amplifier is not present.

In some embodiments, the mist generating device further comprises a liquid reservoir and a feeding means configured to feed liquid from said reservoir to a surface of said plate.

The mist generating device may have a liquid reservoir and a feeding means configured to feed the liquid from the reservoir to a surface of the plate. In this regard the reservoir may be a water reservoir and the liquid may be water.

In some embodiments said feeding means comprises a conduit extending from said liquid reservoir towards said plate.

The feeding means may comprise a conduit that takes the liquid reservoir towards the plate, in some embodiments the conduit contains an absorbent material, the absorbent material being configured to transport the liquid at least partially by capillary action from the liquid reservoir to a surface of the plate.

Such absorbent material provides a cost effective, continuous supply of liquid to the plate that does not require an external driving force.

In some embodiments, said conduit extends perpendicularly towards a lower surface of said plate from said reservoir.

A convenient arrangement may be for the conduit to extend perpendicularly from the reservoir towards a lower surface of the plate. The porous material within the conduit may fill the conduit and in some embodiments the conduit and the porous material will have a circular cross section. In some cases the porous material may be formed in two parts, the upper part of which that contacts the lower surface of the plate being a softer more compliant material which acts as an interface layer providing good and even contact across the plate and the lower portion comprising the main absorber which is a less compliant material. The plate that is contacted is in some embodiments formed as a mesh.

In some embodiments, said mist generating device further comprises a tube extending perpendicularly away from an upper surface of said plate.

In some embodiments, the lower end of said tube is located at a predetermined distance from the said upper surface of said plate, said predetermined distance being selected so as to controllably restrict a flow of air to said plate.

In some cases there may be a tube extending above the plate and forming a guide means for the mist that is generated. There is a flow of air that travels down around the outer surface of the tube and flows around the lower end and then up the inner surface of the tube, the flow within the tube entraining the water droplets formed by the piezoelectric transducer and providing the steam or smoke effect. The distance between the lower end of the tube and the upper surface of the plate affects the amount of air flow. The amount of air flow will affect the density of the mist generated and thus, can be used to control the appearance of the steam/smoke output by the mist generating device. The distance between the plate and the tube may be varied by moving one or both of the tube and transducer vertically.

In some embodiments, said plate is supported within a housing, said housing comprises at least one air inlet for allowing a restricted flow of air to said plate.

Alternatively and/or additionally, the flow of air can be controlled by mounting the transducer within a housing and controlling the air inlet to the housing.

In some embodiments, said at least one air inlet comprises a plurality of apertures formed within two concentric annular rings, said annular rings being mounted for relative rotational movement, such that an alignment of said apertures and thus, a flow of air varies with an angular position of said annular rings.

The flow of air into the housing may be controlled using concentric annular rings with vertical apertures that can be aligned to varying degrees to control the air flow.

Alternatively and/or additionally, said housing comprises a porous material between said at least one air inlet and said piezoelectric transducer, said porous material being configured to restrict air flow to said piezoelectric transducer.

The porous material may be a soft flexible material which assumes the shape of the housing and restricts the air flow. In this regard, the mist generating device may be used in different locomotives which have different body shapes. In some cases the body shape may make air restriction means such as annular rings an inappropriate means of restricting air flow. In such cases, providing a porous material which restricts air flow and in some embodiments assumes the shape of the housing may be a cost effective and convenient way of controlling air flow. In this regard, the more of the volume around the transducer that is taken up with this material the less air there is available for the active nebulizing. This has the effect of reducing the velocity of the emitted exhaust as well as increasing the density and thus, the whiteness of the mist.

In some embodiments the tube extending above the plate is fixed to the transducer upper surface. The flow of air may be controlled by a variation of the volume in the lower end of tube in contact with the transducer upper surface.

In some embodiments, the mist generating device comprises an absorbent material configured to absorb liquid condensing on or close to said plate and configured to transfer said liquid away from said plate.

One potential problem associated with piezoelectric transducers used for mist generation is that the liquid, in some cases water, condenses on or close to the plate and impedes its ability to atomise further liquid. This is addressed in embodiments by using an absorbent material located to absorb water at or close to the plate and transfer the liquid away from the plate.

In some embodiments, the mist generating device further comprises a funnel located above an upper surface of said plate for directing said mist upwards, said mist generating device comprising an absorbent material configured to absorb liquid condensing on an inner surface of said funnel and to transfer said liquid away from said inner surface of said funnel.

Where a tube or funnel is located above the upper surface of the plate to direct the mist away from the plate there may also be problems associated with water condensing on the inner surface of this tube or funnel. Thus, in some embodiments an absorbent material may be used to remove water condensing on the inner surface of this funnel. It should be noted that suitably arranged absorbent material can be used both for removing water from the upper surface of the plate and from the inner surface of such a funnel.

In some cases, the absorbent material is configured to transfer the liquid to the liquid reservoir.

Although, the absorbent material may simply be used to transfer the liquid away from the mist generating device, in some cases it transfers it back to the liquid reservoir thereby prolonging the time intervals between which the liquid reservoir needs to be refilled during operation.

In some embodiments, said plate comprises a protrusion with a circular cross section extending from a central portion of a lower surface of said plate.

It may be advantageous to provide a protrusion on the plate on the piezoelectric transducer. This protrusion may have a dome shape or a truncated dome shape. Such a protrusion helps focus the atomised liquid and provides a directed plume of droplets. In some cases, it may be advantageous if the protrusion extends from a lower surface of the plate as this improves the contact with the liquid where liquid is supplied to the plate from the under surface.

In some embodiments, said piezoelectric transducer comprises an annular shaped piezoelectric transducer element surrounding and connected to said plate, said plate comprising a fine mesh, vibration of said plate atomising liquid contacting a lower surface of said plate.

Although the piezoelectric transducer may have a number of forms, in some embodiments it comprises an annular shaped element surrounding and connected to a plate. The plate may comprise a fine mesh such that water contacting an under surface can be atomised and expelled at the upper surface. An electric signal transmitted to the piezoelectric element causes the plate to vibrate and atomise the liquid contacting the lower surface.

A second aspect provides a model steam or diesel train comprising the mist generating device of a first aspect.

In some embodiments, the mist generating device is located within a confined space within the train housing, said confined space being configured such that an airflow to said confined space is restricted.

One way of restricting the air flow to the mist generating device and thus, control the density of the mist that is output, may be to locate the mist generating device within a confined space and restrict the air flow to the confined space. In this regard, the mist generating device will be located within a relatively small space in that model steam or diesel locomotives are relatively small. Where it is desired to restrict the air flow to the device then the confined housing may be sealed with controllable air inlets or may be filled with some porous material which restricts the flow.

In some embodiments, said confined space comprises an air inlet with a controllable aperture, such that said restricted flow of air is controllable by a size of said aperture.

Alternatively and/or additionally, said confined space comprises a porous material configured to restrict said flow of air to said piezoelectric transducer.

Further particular and preferred aspects are set out in the accompanying independent and dependent claims. Features of the dependent claims may be combined with features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

Where an apparatus feature is described as being operable to provide a function, it will be appreciated that this includes an apparatus feature which provides that function or which is adapted or configured to provide that function.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described further, with reference to the accompanying drawings, in which:

Figure 1 illustrates a first embodiment of the synchronised smoke generation system within a locomotive attached in this case to a tender;

Figure 2 illustrates a more detailed drawing of the mist generator illustrated in Figure 1;

Figure 3 illustrates an angular air flow control system using vertically aligned holes to control the airflow for use with the mist generator of Figure 2;

Figure 4 illustrates a more detailed drawing of the exhaust generator for use in areas where the space envelope available is reduced;

Figure 5 illustrates an alternative angular air flow control system using horizontally aligned cut-outs to control the flow of air as illustrated in Figure 4;

Figure 6 illustrates a second exemplary embodiment of the synchronised smoke generation system showing the detailed parts of the overall system and the electrical interconnections between them;

Figure 7 illustrates the electrical waveforms observed and the timing relationship between each part of the electrical circuit as illustrated in Figure 6; and

Figure 8 illustrates a more detailed drawing of a means used to remove unwanted condensed water vapour from within the exhaust channel.

DESCRIPTION OF THE EMBODIMENTS

Before describing embodiments in detail, first an overview will be given.

Embodiments provide a system that uses a focussed electro-acoustic (piezoelectric) atomiser transducer as the mechanism by which the exhaust is generated. The effect of the mechanical focus is to create a high exit velocity for the atomised fluid (exhaust). This technique obviates the need for an additional driving mechanism such as an electric fan to create the same exhaust velocity effect and provides a rapid response to changes in the driving signal, allowing for a highly controllable simulated steam effect.

The on/off response times of the electro-acoustic transducer times are very rapid and this enables the exhaust emissions of a steam or diesel locomotive to be accurately replicated. Furthermore, the “steam” output can be synchronised to the loudspeaker audio output in an effective way such that the ‘chuffs’ of simulated steam can be output at the same rate as the sounds generated by a sound decoder. This sound is generated to change with the speed and in some cases loading of the locomotive.

In some embodiments the electrical waveform that is applied to the audio loudspeaker from the DCC sound decoder is also used as the synchronisation timing reference for the mist generator device. This reference signal is modified and then used to trigger an additional waveform, the frequency and amplitude of which is suitable to drive the focussed atomiser transducer which generates the simulated steam exhaust. This allows the audio and visual effects to be accurately synchronised together.

This accurate synchronisation of the visual exhaust to the audio output and the fast responsiveness of the piezoelectric transducer allows both the time duration of each individual 'chuff' and its repetition rate to closely follow that created by the DCC recorded sounds. Using this technique the synchronisation of the smoke-to-sound produces a much more realistic imitation of a full size locomotive exhaust.

Furthermore, the compact nature of the piezoelectric device and the lack of requirement for an electrical fan enables the fuel/water carrying capacity to be increased. This in turn has increased the time duration between refills from the currently available oil-based systems of about 3 to 10 minutes to between 30 minutes and ~~to~~ several hours depending upon the volume and density of smoke generated. This is a huge improvement over the conventional vaporised oil method. Furthermore, in some embodiments, a feedback path for collecting water condensing on or near the surface of the piezoelectric vibrating plate and/or on the inner surface of the funnel and feeding it by capillary action, back to the water reservoir also increases the time between reservoir refills. This is particularly important when the locomotive exhaust is being expelled continuously. Furthermore, by returning the condensed liquid to the reservoir any physical or electrical damage to the railway track and surrounding rea from the liquid is avoided or at least reduced.

Furthermore, Health and Safety and Environmental effects are increasingly important considerations, especially if the general public are to be able to see and use this method safely. With this in mind the cheapest, safest and most appropriate fluid to generate the steam/smoke exhaust vapour effect is water. Other low viscosity fuels may be used but experimentation has shown that the cheapest and safest fluid is distilled-water.
The use of a piezoelectric vibrating plate allows the exhaust vapour to be expelled at room temperature. If distilled water is used there will be no harmful effects associated with the inhalation of the vapour.

Furthermore, there are no excessively high temperatures or pressures generated by the vaporising transducer and its associated electronics which means that it is a 'safe' technology. These considerations are especially important when the system is being uses in environments such as model railway exhibitions and personal layouts where close human participation is likely.

A further advantage is that unlike the oil based systems which require electrical heating elements, both the transducer (piezoelectric plate) and system electronics will not be damaged if the system runs out of vaporising fluid whilst still active.

Furthermore, the ability to dispense with both the electrical fan and heating element means that the current drawn from the power supply is greatly reduced.

The piezoelectric device comprises an ultrasound generator that is inaudible to humans and animals as it uses a frequency range above 100 kHz.

Figure 1 shows a model locomotive according to an embodiment. In this embodiment a steam locomotive is paired with a tender, which in this particular case contains the control electronics in the form of a DCC sound decoder 16 and interface PCB 17. Contained within the body of the locomotive outline are the components for storing the liquid and generating the exhaust, in this embodiment exhaust generator 1 and fluid reservoir 12. The electrical pick-ups and loudspeaker 14 are also shown in the body of the locomotive, although the loudspeaker 14 may be situated in either the locomotive or the tender depending on the available space.

The embodied invention is relatively simple in construction, it has no moving parts and the interface printed circuit board 17 allows it to be easily interfaced with most of the currently available DCC Sound decoders 16.

Figure 1 schematically illustrates the construction of a typical model railway steam locomotive with an attached tender. This has a focussed piezoelectric vaporising mesh transducer 1 fitted below the funnel 4. The upper side of the transducer assembly 1 contains the piezoelectric element and is open to the atmosphere. The lower side (mesh) is in contact with the vaporising fluid supplied from reservoir 12 through the capillary action of an absorbent material, in this embodiment a cotton filter 11. In some embodiments, cotton filter 11 is formed in two portions, the upper portion being a softer more compliant material than the lower portion, this upper portion acting as an interface layer to the main absorber (in the lower portion) smoothing out any irregularities or alignment issues with the transducer. The fluid reservoir 12 can be filled through entry point 34.

The locomotive further comprises a drive motor 13 for propelling the locomotive along the track, electrical wheel pick-ups 18 on the chassis and in this example an audio loudspeaker 14, these are connected to the interface Printed Circuit Board (PCB) 17 via a signal conduit 15. An acoustic detector (hydrophone) 35 is placed in close proximity to the loudspeaker 14 to accurately detect the audio output. The interface board 17 contains electronic control and drive circuitry configured to drive the transducer 1 in response to an electrical waveform containing the audio signal which is applied to the loudspeaker 14.

The DCC (digital command control) sound decoder 16 and interface PCB 17 are joined together, with a standard 8 pin NMRA (national model railway association) connector system although other DCC type interconnections may be used. Both DCC sound decoder 16 and interface 17 are located in the tender in this particular example but in other embodiments, they may be located at alternative locations dependent upon the space available.

Referring to Figure 1, the electrical signals to control and power the locomotive are, for this example, contained within the rails and are transferred to the control electronics 16 and 17 by means of pick-ups 18 located on the chassis and which are in contact with the wheels.

When a suitable electrical drive signal is applied to the focussed electroacoustic transducer 1 via the transmission conduit 9 the transducer 1 is activated and emits a jet of vaporised fluid 6 vertically upwards. The water vapour passes through an exhaust conduit in the form of a tube 7 which is located directly underneath the funnel 4 before exiting ~~and~~ into the atmosphere. The action of the transducer mechanical focus causes an increase in exhaust vapour density and velocity with respect to a non-focussed device and as such improves the quality of the simulated steam. In this embodiment the focus comprises a dome shaped protrusion extending from an upper surface of the transducer plate, in other embodiments the focus may extend in the other direction from the lower plate, an advantage of this being that the contact with the liquid is improved. Although the protrusion is shown as a dome shape in some embodiments, it may be an inverted and horizontally truncated dome.

In the embodiment shown reservoir 12 has a small opening 34 which can be used to input additional liquid such as distilled water, using a syringe. In some embodiments, air flow control means for controlling the air flow to the transducer are also present and act to increase the exhaust vapour density and thus, improve the simulated steam effect.

The reduction of air flow into chamber 5 causes the exhaust vapour to become more dense. In some cases this can have the negative effect of the exhaust conduit 7 and transducer 1 upper surface becoming covered with a layer of condensed water. This can block the exhaust conduit and stops the locomotive emitting any exhaust. To address this problem a thin water absorption material 39 is inserted into the exhaust conduit extending towards and in some cases touching the transducer surface. This uses capillary action to soak up the excess condensed water and convey it back into the water reservoir 12 via tube 37.

Figure 2 illustrates a more detailed view of the mist generator assembly. Here, the transducer 1 is located within a transducer holder 3, the holder 3 being free to move up and down in a vertical direction within stationary housing 2. An 'O ring' 10 is used to seal the gap between the stationary housing 2 and the transducer holder 3, which also acts as a water feed conduit, the O-ring stops or at least impedes water escaping from the reservoir. In this embodiment it is only the transducer holder 3 that can move vertically to vary the distance d.

The velocity and density of the exhaust vapour or steam 6 is dependent upon the rate of flow of air entering chamber 5 and then exiting to the outside atmosphere through tube 7 and chimney 4.

The in/out airflow rate into chamber 5 can be controlled in a number of ways, namely by:-

i). The use of two rings (8a and 8b) shown in Figure 3. These have a number of vertically machined cut-outs or apertures in them which allow air to pass through. The relative angular position of the rings with respect to each other is used to control the rate of airflow into the chamber 5.

ii). Alternatively and/or additionally by a variation of the internal and/or external diameters of tube 7 and the length and position of tube 7 within the fixed funnel 4.

(iii) Alternatively and/or additionally by varying the distance d between the lower end of the tube 7 and the upper surface of the transducer 1 by the vertical movement of transducer holder 3 or the vertical movement of tube 7 or both.
(iv) Alternatively and/or additionally by providing air restrictive means in the form of a porous material to restrict air flow between openings in the upper side of the chamber 5 and the transducer.

Referring now to Figures 4 and 5: for the condition where the available space envelope within the locomotive body is restricted, the upper part of housing 2 is removed along with rings 8a and 8b.

A horizontal machined cut-out to allow air into chamber 5 is made in Tube 7 which is then permanently attached to the transducer 1 upper surface using a pliable material so as not to affect the performance of the said transducer.

This complete assembly comprises transducer 1, transducer holder 3, tube 7 and cotton filter 11. This said assembly is free to move up and down in a vertical direction within the locomotive body by a distance d which is the free space between the top of the tube and the base of the chimney. The 'O' ring 10 ensures that no water escapes from the water reservoir 12 during or after any movement.

To ensure a smooth uninterrupted flow of vapour within the upper part of the exhaust conduit the inside diameter i/d2 of tube 7 is made the same as that of the chimney 4. An additional rotatable ring 7a with a horizontal cut-out is placed over the top of tube 7. When the cut-outs are in perfect alignment the condition of max air flow into chamber 3 is achieved.

The clockwise or anti-clockwise angular movement of ring 7a relative to tube 7 is used to control the rate of airflow into the chamber 5.
i). Alternatively and/or additionally the density of the exhaust vapour can be controlled by a variation of the inside diameter i/d 1 of tube 3 and the height h between the air inlets and bottom of tube 7.
ii). Alternatively and/or additionally by a variation of the number and size of the cut-outs on tube 7 and ring 7a.

Figure 6 schematically shows an electrical block diagram of the mist generating system and its associated electrical interconnections. As previously described the DCC sound decoder 16 is electrically connected to the electronic interface board 17 via a standard 8 pin NMRA (National Model Railway Association) connector system. Alternative standard connectors may be used dependent upon the type of decoder fitted. Fitted within the DCC sound decoder board 16 is a 'Class D' power amplifier 19. This drives the audio loudspeaker 14 with an electrical waveform derived from the digitally stored sound files located within the on-board memory bank of sound decoder 16. These sounds are often those recorded from the actual full size class of locomotive.

An additional 'D class' power amplifier 31 is used to drive the motor 13 which conveys the locomotive around the track.

Power supply conversion and control signals from the track pick-ups 18 are received, conditioned and distributed on the DCC sound decoder 16 by circuitry 32 and on the interface board 17 by a full wave rectifier bridge and its associated DC-DC converter 30. The output 29 of circuitry 30 is set to 5VDC and acts as the supply voltage reference for all the interface board electronics.

When the audio waveform is transmitted from power amplifier 19 to the audio loudspeaker 14 it contains the switching frequency of the 'Class D' amplifier output. This is shown as waveform A in Figure 7.

In this form it can be seen that it is difficult for the position of the audio signal contained within waveform A to be determined. As such, waveform A cannot be used as the direct trigger source to synchronise the drive to the transducer producing the exhaust or steam.

To recover the audio output, waveform A is initially passed through an electrical filter 2 which removes the switching frequency of the power amplifier 19. In other embodiments, where the driving signal is not generated from the output of the sound decoder A, but rather from a signal output from a hydrophone 35 detecting the audio output of the loudspeaker 14, then the signal from the hydrophone may be transmitted to an amplifier 36 which is also connected directly to circuitry 21.

The output waveform of the electrical filter 20 is illustrated by waveform B in Figure 7 and is an accurate representation of the audio sound file from the original locomotive recording.

This waveform is the applied to circuitry 21 where it is half-wave rectified and has the audio carrier frequency removed to reveal the positive half of the envelope C of the transmitted acoustic waveform B. Waveform C is then applied to one of two inputs of a voltage comparator 23.

A reference voltage, D set by the output of reference signal circuitry 22 is applied to the other input of comparator 23. When the amplitude of C is greater than the level set by D the comparator output E generates a logic level '1' signal. This waveform is applied to one of the inputs of a Logic gate 24. Also present at the Logic gate input is the waveform H from the output of oscillator 27. The frequency of the oscillator 27 generating waveform H is set to the same frequency as the resonant frequency (Fr) of the piezoelectric mist generator transducer 1.

In some embodiments there may be a third input G also input to Logic gate 24. This signal is derived from the Sound decoder 16 using circuitry 33 and is included because some DCC sound decoders generate their own digital output waveform F which is synchronised to the audio output waveform A.

It is possible that waveform F is not compatible with the input requirements of Logic gate 24. For this reason, signal conditioning circuitry 28 is inserted to correct for this. If this signal is not available or not required then this input is set to logic level '1'.

Adjustment of comparator reference level D controls the intensity and duration of the exhaust emissions.

The output I from logic gate 24, which in this embodiment is an AND gate, is a gated signal containing an underlying frequency required to drive the smoke generator transducer at its natural mechanical resonance (Fr). The waveform I is applied to the input of Driver/MOSFET circuitry 25 which in turn drives the step-up transformer 26. The transformer steps up the applied signal voltage to drive the transducer 1 at the correct amplitude level.

The output signal I from logic gate 24 which drives the exhaust generator 1 has an on and off time duration which is virtually identical to the on and off durations of the audio waveform B. As they both occur together at precisely the same time it can be stated that the two waveforms are synchronised together.

In this way the mist generating signal is synchronised to the sound from the sound decoder. It should be noted that the coded signal picked-up from the rails by the wheel contacts 18 is constantly updated as the speed and load conditions of the locomotive vary. This signal is conveyed to the DCC decoder 16 which adjusts the electrical output to the audio loudspeaker 14 and drive motor 13 to reflect the change in the said speed and load conditions of the locomotive.

The decoded on/off time duration and amplitude of electrical output signal B is dependent upon the speed and load condition respectively of the locomotive at any instant in time.

Figure 8 shows a more detailed cross section through the mist generating device of an embodiment and in particular shows how liquid collecting on the transducer and within pipe 7 is collected by an absorbent material 39 and returned to the water reservoir 12. The absorbent material 39 extends along the inner surface of tube 7 and contacts the upper surface of transducer 1. This absorbent material absorbs liquid form the inside of the tube and from the surface of transducer 1 and carries it by capillary action to return it to water reservoir 12. The water reservoir 12 is fitted with an entry tube 40 which connects to tube 37. The inset in Figure 8 shows this arrangement in more detail. There is a slotted sealing bush 38 which anchors the absorbent material within the flexible tube 39 by folding it back over itself.

It should be noted that embodiments of the mist generator described above may be used with a railway steam locomotive with an attached tender and equally with non-tender and diesel locomotives across a wide range of scales.

In addition, solutions to locomotives with more than one exhaust orifice can be represented by using a suitable number of mechanical structures such as pipes or the introduction of more transducers.

Other features such as the simulation effects of whistles, safety valve and cylinder cock emissions can be reproduced by adding more transducers and modifying the electronics 16 and 17.

In summary a simulated smoke generation system for use in model railway locomotives and model toys, which is synchronised to the audio output of the loudspeaker and, in addition, provides for the variable control of the density and velocity of the exhaust emitted from the exhaust outlet pipe(s) (diesel) or chimney (steam) is disclosed.

To more accurately represent the characteristic of a full size railway steam or diesel locomotive, the visible exhaust should be accurately synchronised to the generation of the transmitted sound from an associated audio loudspeaker.

Embodiments have succeeded in achieving the above requirement using a 'mechanically focussed' piezoelectric mesh transducer as the method of simulating the steam/smoke exhaust of a railway locomotive.

By controlling the rate of change of airflow available to the transducer output it is possible to vary the density of the water vapour exhaust.

In doing so, a far more accurate imitation of the steam/smoke exhaust of a railway locomotive can be achieved than is currently available.

In addition, because the rise and fall time of the exhaust generator transducer itself is virtually instantaneous it has been possible to create a much more accurate and hence realistic effect of the combined audio/visual timing of the exhaust characteristics of a full-size locomotive in miniature.

Embodiments comprise a focussed ultrasonic vaporising device for generating the exhaust characteristics of a model railway locomotive or other model toy and a method of synchronising the said exhaust characteristics to the associated audio output of the device, embodiments of the device comprising;

- a focussed piezoelectric metal mesh vaporising transducer (exhaust generator) including a pair of electrodes connected to the piezoelectric element which is situated on the upper surface of the said exhaust generator,
- a housing for securing the said exhaust generator transducer,
- a means of supplying the vaporising fluid to the lower (mesh) side of the exhaust generator using capillary action,
- a reservoir to store the fluid to be vaporised,
- a bore in the said fluid reservoir to add the said vaporising fluid,
- a means of removing condensed water vapour from the exhaust conduit and returning it to the said reservoir,
- a waveform generator suitable for exciting the said exhaust generator,
- a means of connecting the said waveform generator to the said electrodes of the exhaust generator,

- an audio loudspeaker with electrodes connected to the DCC sound decoder output audio waveform,
- a said waveform generator to excite the said exhaust generator with a waveform synchronised to the said audio waveform applied to the audio loudspeaker,

A method of adapting and conditioning the said audio waveform applied across the audio loudspeaker electrodes into a form suitable for the said waveform generator to drive to the said exhaust generator so that they are synchronised together is also disclosed.

A method of detecting and conditioning a ‘trigger’ waveform which is synchronised to the said audio waveform applied across the audio loudspeaker electrodes into a form suitable for the said waveform generator to drive to the said exhaust generator so that they are synchronised together is also disclosed.

A method of acoustically detecting the audio loudspeaker sound output and converting the sound into a form suitable to drive the said exhaust generator so that they are synchronised together is also disclosed.

A method of controlling the airflow into the said exhaust generator chamber consisting essentially of a device with shaped adjustable bores is provided.

A method of controlling the airflow into and out of the said exhaust generator chamber comprising a tubular device with adjustable internal and external bores and height is also provided.

Although illustrative embodiments of the invention have been disclosed in detail herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiment and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined by the appended claims and their equivalents.

CLAIMS

1. A mist generating device comprising:

a piezoelectric transducer configured to vibrate a plate and atomise liquid contacting said plate to generate said mist; and

a signal generator for generating a driving signal for driving said piezoelectric transducer, said signal generator comprising:

an input for receiving a signal indicative of a sound made by a steam or diesel locomotive; and

circuitry configured to generate a signal synchronised to said received sound signal and to output said signal as said driving signal.

2. A mist generating device according to claim 1, wherein said received signal indicative of a sound made by a steam or diesel locomotive is a signal indicative of a sound made by a steam or diesel locomotive travelling at one of a plurality of different speeds and loads.

3. A mist generating device according to claim 1 or 2, said mist generating device further comprising a sound decoder for storing locomotive sounds and configured to generate signals indicative of said locomotive sounds;

a loudspeaker configured to receive said signals from said sound decoder and to output said locomotive sounds; wherein

said locomotive sound received by said signal generator is a signal indicative of said sound signal output by said loudspeaker.

4. A mist generating device according to claim 3, wherein said signal indicative of said sound signal comprises a signal received from said sound decoder said signal generator processing said signal to generate said driving signal.

5. A mist generating device according to claim 3, wherein said signal indicative of said sound signal comprises a signal generated by acoustically detecting an output of said loudspeaker.

6. A mist generating device according to any preceding claim, wherein said circuitry of said signal generator comprises at least one of an electrical filter and signal conditioning circuitry configured to generate said driving signal from peaks in said sound output from said sound decoder indicative of a length and amplitude of a chuff.

7. A mist generating device according to any preceding claim, further comprising: a liquid reservoir and a feeding means configured to feed liquid from said reservoir to a surface of said plate.

8. A mist generating device according to claim 7, wherein said feeding means comprises a conduit extending from said liquid reservoir towards said plate.

9. A mist generating device according to claim 8, said conduit containing an absorbent material, said absorbent material being configured to transmit liquid at least partially by capillary action from said liquid reservoir to a surface of said plate.

10. A mist generating device according claim 8 or 9, wherein said conduit extends perpendicularly towards a lower surface of said plate from said reservoir.

11. A mist generating device according to any preceding claim, said mist generating device further comprising a tube extending perpendicularly away from an upper surface of said plate.

12. A mist generating device according to claim 11, wherein a lower end of said tube is located at a predetermined distance from said upper surface of said plate, said predetermined distance being selected so as to controllably restrict a flow of air to said plate.

13. A mist generating device according to any preceding claim, said plate being supported within a housing, said housing comprises at least one air inlet for allowing a restricted flow of air to said plate.

14. A mist generating device according to claim 13, wherein said at least one air inlet comprises a plurality of apertures formed within two concentric annular rings, said annular rings being mounted for relative rotational movement, such that an alignment of said apertures and thus, a flow of air varies with an angular position of said at least one of said annular rings.

15. A mist generating device according to claim 13 or 14, wherein said housing comprises an opening and a porous material between said opening and said

piezoelectric transducer, said porous material being configured to restrict air flow to said piezoelectric transducer.

16. A mist generating device according to any preceding claim, comprising an absorbent material configured to absorb liquid condensing on or close to said plate and configured to transfer said liquid away from said plate.

17. A mist generating device according to any preceding claim, said mist generating device further comprising a funnel located above an upper surface of said plate for directing said mist upwards, said mist generating device comprising an absorbent material configured to absorb liquid condensing on an inner surface of said funnel and to transfer said liquid away from said inner surface of said funnel.

18. A mist generating device according to claim 16 or 17, when dependent on claim 7, said absorbent material being configured to transfer said liquid to said liquid reservoir.

19. A mist generating device according to any preceding claim, wherein said plate comprises a protrusion with a circular cross section extending from a central portion of a lower surface of said plate.

20. A mist generating device according to any preceding claim, wherein said piezoelectric transducer comprises an annular shaped piezoelectric transducer element surrounding and connected to said plate, said plate comprising a fine mesh, vibration of said plate atomising liquid contacting a lower surface of said plate.

21. A model steam or diesel train comprising said mist generating device according to any preceding claim.

22. A model steam or diesel train according to claim 21, said mist generating device being located within a confined space within the train housing, said confined space being configured such that an airflow to said confined space is restricted.

23. A model steam or diesel train according to claim 22, wherein said confined space comprises an air inlet with a controllable aperture, such that said restricted flow of air is controllable by a size of said aperture.

24. A model steam or diesel train according to claim 22 or 23, wherein said confined space comprises a porous material configured to restrict said flow of air to said piezoelectric transducer.