(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 404 221 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.07.2024 Bulletin 2024/30

(21) Application number: **23152659.1**

(22) Date of filing: **20.01.2023**

(51) International Patent Classification (IPC):
H01F 27/33 (2006.01) ***G10K 11/172*** (2006.01)

(52) Cooperative Patent Classification (CPC):
H01F 27/33; G10K 11/172; H01F 27/02; H01F 27/025

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(54) DEVICE FOR REDUCING NOISE CAUSED BY A TRANSFORMER AND SYSTEM

(57) The present disclosure relates to a device (10) for reducing noise caused by a transformer (12), including at least one sound-reducing element (16) configured to be arranged on an exterior of the transformer (12) and including at least one duct (18) arranged in a meandering pattern and configured to attenuate one or more sound-waves received from the transformer (12).

The present disclosure also relates to a system including at least one transformer (12) and at least one device (10) according to any of the embodiments described herein which is arranged on an exterior of the at least one transformer (12).

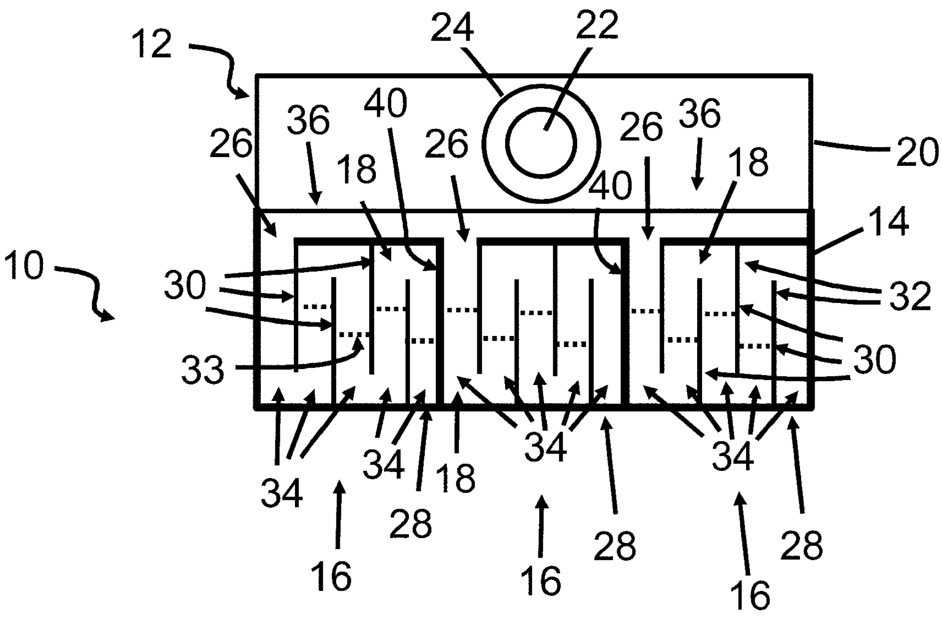

Fig. 1

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Description

Background

[0001] Transformers are widely used to convert electricity from a first voltage level to a second voltage level, the second voltage level being either similar, higher or lower than the first voltage level. During operation, transformers may generate and emit a considerable amount of noise, in particular audible noise, which may have one or more adverse effects, in particular on an environment of the transformer. For instance, the noise may be uncomfortable and/or annoying and/or harmful and/or painful to persons who may be subjected to the noise, in particular for an extended period of time. Moreover, for instance, the soundwaves emitted by the transformer may be coupled to one or more vibrations, e.g., by exciting one or more surfaces, which may also have one or more adverse effects in the environment.

[0002] As transformers have become more compact and are limited by their respective footprint, it may be desirable to provide a relatively compact means for reducing the noise caused by transformers. Additionally, or alternatively, it may be desirable to provide a relatively effective and/or efficient means for reducing noise caused by transformers.

[0003] However, the known prior art has not, or at least not sufficiently, provided means for reducing noise caused by transformers to the desired extent, e.g., by addressing one or more of the above-identified issues.

[0004] Thus, the present disclosure describes one or more aspects for providing improved means for reducing noise caused by a transformer.

[0005] The above and other aspects and their implementations are described in greater detail in the drawings, the descriptions, and the claims.

[0006] Various exemplary embodiments of the present disclosure disclosed herein are directed to providing features that will become readily apparent by reference to the following description when taken in conjunction with the accompanying drawings. In accordance with various embodiments, exemplary devices are disclosed herein. It is understood, however, that these embodiments are presented by way of example and not limitation, and it will be apparent to those of ordinary skill in the art who read the present disclosure that various modifications to the disclosed embodiments can be made while remaining within the scope of the present disclosure.

[0007] Thus, the present disclosure is not limited to the exemplary embodiments and applications described and illustrated herein. The above and other aspects and their implementations are described in greater detail in the drawings, the descriptions, and the claims.

Description of the Drawings

[0008]

Fig. 1 schematically shows, in a top view, a device for reducing noise caused by a transformer according to an embodiment of the present disclosure;

Fig. 2 shows a diagram of a pressure distribution in a duct of the device shown in Fig. 1;

Fig. 3 shows a diagram of a particle velocity distribution in a duct of the device shown in Fig. 1.

[0009] In the following, exemplary embodiments of the disclosure will be described. It is noted that some aspects of any one of the described embodiments may also be found in some other embodiments unless otherwise stated or obvious. However, for increased intelligibility, each aspect will only be described in detail when first mentioned and any repeated description of the same aspect will be omitted.

[0010] The present disclosure relates to a device for reducing noise, in particular audible noise, caused by a transformer. The device may include at least one sound-reducing element. The at least one sound-reducing element may be configured to be arranged on an exterior of the transformer. The at least one sound-reducing element may include at least one duct. The at least one duct may be arranged in a meandering pattern. The at least one duct may be configured to attenuate one or more soundwaves received from the transformer to reduce noise of the transformer.

[0011] Configuring the at least one sound-reducing element with the at least one duct and configuring the at least one duct to receive one or more soundwaves from the transformer may allow the at least one duct to interact with the one or more soundwaves from the transformer to reduce noise of the transformer. For instance, the at least one duct may at least partially trap at least a portion of the soundwaves within the at least one duct, at least temporarily, and/or the at least one duct may interact with the one or more soundwaves to cause a change in one or more properties of the one or more soundwaves, e.g., in at least one amplitude of the one or more soundwaves. Alternatively, or additionally, the at least one duct may be configured to reduce a velocity of at least one medium, e.g., air, in particular of one or more particles of the at least one medium, in which the soundwaves are propagated, e.g., via friction between the medium and at least a section of the at least one sound-reducing element, e.g., at least one wall which borders and/or defines the at least one duct. For instance, this may cause damping of the one or more soundwaves to reduce and/or mitigate and/or attenuate noise caused by the transformer. Alternatively, or additionally, a plurality of the soundwaves may at least partially cancel each other out within the at least one duct. Thus, this may allow the noise generated by the transformer to be reduced relatively effectively and/or efficiently.

[0012] The term "meandering pattern" may be understood such that the at least one duct may follow a path which causes the one or more soundwaves to be continuously, for at least one or more sections of the at least one duct, or discontinuously, for at least one or more sections of the at least one duct, redirected. In other words, the "meandering pattern" of the at least one duct may cause a direction in which the one or more soundwaves propagate, or a medium such as air may travel, through the at least one duct to be changed/altered, continuously, for at least one or more sections of the at least one duct, or discontinuously, for at least one or more sections of the at least one duct. For instance, the meandering pattern may be configured as a spiral, a swirl, a maze, a wave, or any other path which continuously and/or non-continuously causes a change in the direction of the at least one duct. In particular, the at least one duct may be configured to redirect the one or more soundwaves along a path of propagation of the one or more soundwaves through the at least one duct at least 2 times, more particularly at least 3 times, more particularly at least 4 times, more particularly at least 5 times. Alternatively, or additionally, the at least one duct may be configured to redirect the one or more soundwaves continuously along at least a section of the at least one duct, e.g., by a curved and/or spiral form of the at least one section of the at least one duct. The at least one duct may include at least one curved section and/or at least one curved and/or angled section, e.g., at least one section which is angled in a range from 1° to 180°, particularly from 45° to 180°, more particularly from 90° to 180°, for redirecting the one or more soundwaves through the at least one duct. The at least one duct may extend concentrically for at least a section thereof and/or non-concentrically for at least a section thereof.

[0013] Arranging the at least one duct in a meandering pattern may allow the at least one duct to be configured relatively compactly, e.g., compared with a duct which extends in a substantially straight line, while providing a relatively effective and/or efficient reduction in noise caused by the transformer. This may allow the at least one duct to be configured to be relatively long and/or have a relatively large volume/space, while minimizing the space/volume which the at least one sound-reducing element, in particular the at least one duct, consumes. Hence, this may provide a space-spacing means for effectively and/or efficiently reducing noise caused by transformers.

[0014] The at least one sound-reducing element may be configured as an insert which may be mounted, preferably releasably mounted, e.g., to at least one support structure and/or directly to at least one surface, preferably at least one outer surface, of the transformer.

[0015] The at least one sound-reducing element may be arranged, positioned and/or oriented, e.g., relative to the transformer, in a number of ways. For instance, the sound-reducing elements may be arranged without spacing between adjacent sound-reducing elements. Alternatively, the sound-reducing elements may be arranged periodically and/or spaced apart from each other, e.g., at one or more intervals. Additionally, or alternatively, the sound-reducing elements may be arranged according to and/or matching a shape or contour, in particular an outer contour, of the transformer. The sound-reducing elements may be arranged in-line, e.g., in a straight line, and/or along a curve or bend, etc.

[0016] The device disclosed herein may be used with any type of transformer to reduce noise of the respective transformer. Thus, the device disclosed herein is not limited to an application with one or more specific types of transformers. For instance, the transformer may be a reactor.

[0017] The at least one duct may include at least one inlet opening which faces the transformer, when the at least one sound-reducing element is arranged on the exterior of the transformer. The at least one inlet opening may be configured to receive one or more soundwaves from the transformer. Hence, configuring the at least one duct with at least one inlet opening which faces the transformer may allow an efficient and effective entrance of the one or more soundwaves into the at least one duct. This may also reduce a distance the one or more soundwaves travel before entering the at least one duct, which may provide an optimized and/or efficient use of space of the at least one sound-reducing element, in particular of the at least one duct.

[0018] The at least one duct may include a closed end. The closed end may be arranged at the end of the path along which the one or more soundwaves propagate through the at least one duct. Thus, configuring the end of the at least one duct to be closed prevents the one or more soundwaves from exiting the at least one duct through the end. This may increase the effectiveness and/or efficiency of the at least one sound-reducing element, in particular the at least one duct, in reducing noise caused by the transformer. Moreover, this may allow the provided volume of the at least one duct to be used efficiently, since the one or more soundwaves may be reversed at the closed end to propagate at least partially through the at least one duct in a reversed direction, in which further sound-reducing effects may be applied to the one or more soundwaves. Alternatively, or additionally, a plurality of the soundwaves may at least partially cancel each other out within the at least one duct, in particular for soundwaves which are traveling in opposite directions through the at least one duct due to the closed end and its soundwave-reflecting properties. Alternatively, the at least one duct may include an open end. For instance, the at least one duct may be open at at least two ends, e.g., at an inlet and an outlet of the at least one duct.

[0019] The at least one sound-reducing element may include a plurality of walls which at least partially define the at least one duct between opposing walls of the plurality of walls. The walls may be configured to redirect the one or more soundwaves along a path of propagation of the one or more soundwaves through the at least one duct. For instance, adjacent walls, with respect to a direction along the at least one duct, may be angled relative to each other, e.g., in a range from 90° to 180°. Alternatively, or additionally, at least a section of at least one of the walls may be curved and/or bent.

[0020] At least some of the walls may be arranged substantially parallel to each other. For instance, one or more pairs of opposing walls, which define at least a section of the at least one duct, may be arranged substantially parallel to each other. Such pairs of opposing walls, which define at least a section of the at least one duct, may provide one or more substantially straight sections of the at least one duct. Alternatively, or additionally, a plurality of walls, which are arranged upstream or downstream from each other, with respect to a direction of propagation of the one or more soundwaves, may be arranged substantially parallel to each other. This may provide a plurality of sections of the at least one duct which extend substantially parallel to each other, in particular wherein the sections of the at least one duct are arranged side by side. This may provide a relatively compact sound-reducing element, more specifically a relatively compact duct.

[0021] The device may further include at least one connecting device which interconnects at least two of the walls, in particular at least two opposing walls of the plurality of walls. The at least one connecting device may be configured as a spacer. This may provide and/or maintain a certain, in particular predefined distance between the walls.

[0022] The at least one connecting device may extend substantially perpendicularly from the respective walls.

[0023] The at least one duct may include a plurality of duct sections which are interconnected. At least some, in particular all, of the duct sections may extend substantially parallel to each other. In particular, at least some of the duct sections, in particular all of the duct sections, may be arranged side-by-side.

[0024] At least some, in particular all, of the duct sections may be arranged such that the one or more soundwaves are redirected from an upstream duct section of the duct sections to a downstream duct section of the duct sections by at least one angle of redirection. The angle of redirection may be at least 30°, particularly at least 40°, more particularly at least 50°, more particularly at least 60°, more particularly at least 70°, more particularly at least 80°, more particularly at least 90°, more particularly at least 100°, more particularly at least 110°, more particularly at least 120°, more particularly at least 130°, more particularly at least 140°, more particularly at least 150°, more particularly at least 160°, more particularly at least 170°, more particularly at least 180°.

[0025] The at least one sound-reducing element may be configured to be coupled to at least one support structure. The at least one support structure may be configured to be arranged, e.g., attached, on the exterior of the transformer. The at least one support structure may be configured to be coupled to an outer surface of the transformer.

[0026] The at least one support structure may be a component of the device described herein. Alternatively, the at least one support structure may be configured as a separate device/component. The at least one support structure may include one or more mounting sections on which the at least one sound-reducing element may be mounted. The at least one support structure may be configured as a housing. Alternatively, or additionally, the at least one support structure may include a plurality of slots and/or channels which may be open towards the transformer and/or an environment of the transformer.

[0027] Alternatively, the at least one support structure may be omitted. For instance, the at least one sound-reducing element may be mounted, e.g., directly, to at least one surface, preferably at least one external surface and/or at least one internal surface, of the transformer.

[0028] The at least one sound-reducing element and/or the at least one support structure may be configured modularly, e.g., such that different types of sound-reducing elements may be combined with and mounted to the at least one support structure. The different types of sound-reducing elements may vary, e.g., in the shape and/or size and/or material and/or one or more further properties of the sound-reducing elements, in particular the shape and/or size of the at least one duct provided in the respective sound-reducing elements. This may allow the sound-reducing elements to be tailored to the requirements of the respective application and/or environment of the respective transformer, e.g., the frequency or frequencies and/or amplitude(s) of the sound emitted by the respective transformer in the respective application of the transformer. However, the at least one sound-reducing element may generally be configured, in particular by configuring the at least one duct accordingly, e.g., its shape and/or size, to cover a relatively broad range of applications, e.g., frequencies and/or amplitude(s) of the sound emitted by the respective transformer, based on a single configuration of the at least one sound-reducing element. For instance, the at least one sound-reducing element may be configured to reduce the noise caused by the transformer at a plurality of different frequencies and/or amplitudes of the one or more soundwaves.

[0029] The at least one support structure may partially enclose the at least one sound-reducing element, in particular a plurality of sound-reducing elements. In particular, the at least one support structure may have at least one support structure opening on a side of the at least one support structure which faces the transformer, such that the one or more soundwaves from the transformer may enter the at least one support structure via the at least one support structure opening in order to be received by the at least one duct of the at least one sound-reducing element. In particular, the at least one support structure opening may extend across the entire side, or at least a relatively large area of the side, e.g., over a predefined area of the at least one support structure which faces the transformer, e.g., at least 10%, 20%, etc.

of an area of the at least one support structure which faces the transformer.

[0030] The at least one support structure may be configured to be mounted on at least one exterior surface of the transformer. Alternatively, or additionally, the at least one support structure may be configured to be mounted at a distance from at least one exterior surface of the transformer. For instance, at least one gap may be arranged at least partially between the transformer and the at least one support structure.

[0031] The at least one support structure may include a plurality of channels. At least one, in particular each, of the at least one sound-reducing element may be arranged at last partially, in particular completely, within a channel of the plurality of channels. The channels thus may at least partially guide or direct the one of more soundwaves from the transformer to the respective sound-reducing element which may increase the effectiveness and/or efficiency of the at least one sound-reducing element in reducing noise caused by the transformer.

[0032] A cross-section of at least a portion of at least some, in particular each, of the channels may be substantially completely filled by one or more of the at least one sound-reducing element, which may optimize a degree of reduction of noise caused by the transformer, e.g., by minimizing the portion of the one or more soundwaves which may propagate past the sound-reducing elements.

[0033] The channels may be at least partially defined by a plurality of ribs extending away from the transformer, when the at least one support structure is arranged on the exterior of the transformer. The ribs may be configured to conduct and dissipate heat from the transformer to an ambient. This may allow the at least one support structure to be combined as a means for receiving/mounting the at least one sound-reducing element and a means for cooling the transformer. The ribs may be made of at least one material, e.g., a metal, which has a relatively high thermal conductivity, e.g., to provide an effective and/or efficient means for conducting heating from the transformer.

[0034] The channels may include at least one channel opening which faces towards the transformer, when the at least one support structure is arranged on the exterior of the transformer. The at least one channel opening may be substantially closed by one or more of the at least one sound-reducing element. This may force a relatively large portion of the one or more soundwaves to propagate to the at least one sound-reducing element and into the at least one duct.

[0035] The at least one duct may be at least partially filled with at least one sound-absorbing material. The at least one sound-absorbing material may be arranged proximate to the at least one inlet opening. This may further enhance the effectiveness and/or the efficiency of the at least one sound-reducing element in reducing noise caused by the transformer. For instance, the sound-absorbing material may reduce at least one amplitude of the one or more soundwaves and/or may reduce at least one velocity of at least one medium, e.g., air, in particular one or more particles of the at least one medium, in which the soundwaves are propagated.

[0036] A total length and/or a width of the at least one duct may be sized based at least partially on at least one wavelength and/or at least one amplitude and/or at least one frequency, in particular one or more dominant frequencies of a plurality of frequencies, of one or more soundwaves which are emitted by the transformer. For instance, a duct length of 286 mm may be chosen, as one quarter (25%) of a wavelength of the one or more soundwaves, at a frequency of 300 Hz.

[0037] A total length of the at least one duct may be from 10% to 50%, in particular from 15% to 45%, in particular from 20% to 40%, in particular from 20% to 35%, in particular from 20% to 30%, in particular substantially 25%, of a wavelength of one or more soundwaves which are emitted by the transformer, e.g., for a frequency of the one or more soundwaves of 300 Hz. The device described herein may be tailored to provide noise reduction for soundwaves having a wide range of different frequencies and/or amplitudes.

[0038] The at least one sound-reducing element may be integrally formed. For instance, the at least one sound-reducing element may be a moulded component, e.g., by manufacturing the at least one sound-reducing element by injection moulding and/or a component made by additive manufacturing. However, the at least one sound-reducing element may be manufactured by means of a variety of further methods, e.g., by extrusion, machining, assembling the components of the at least one sound-reducing element, e.g., adhesively, etc.

[0039] The at least one sound-reducing element may be made of any material which is suitable for the respective application. For instance, the at least one sound-reducing element may be made of at least one of the following materials: acrylonitrile styrene acrylate and a thermoplastic, in particular an amorphous thermoplastic. However, the at least one sound-reducing element may be made of a variety of further materials, e.g., by aluminum and its alloys, steel, etc.

[0040] The at least one duct may be configured to receive and interact with the one or more soundwaves from the transformer to reduce a sound pressure level of the transformer by at least 1 dB, particularly at least 2 dB, more particularly at least 3 dB, more particularly at least 4 dB, more particularly at least 5 dB, more particularly at least 6 dB, more particularly at least 7 dB, more particularly at least 8 dB, more particularly at least 9 dB, more particularly at least 10 dB. The sound pressure level may be measured at a distance of 30 cm from an outer surface of the at least one sound-reducing element.

[0041] The present disclosure further relates to a system which includes at least one transformer and at least one device according to any of the embodiments described herein. The device may be arranged on an exterior of the transformer. The transformer may include at least one receptacle, at least one core, and at least on winding wound at least partially about the at least one core. The device may be arranged on an exterior, in particular on at least one outer surface, of the at least one receptacle.

[0042] The features, embodiments, and advantages discussed herein with respect to the device also apply to the system accordingly.

[0043] The following list of aspects provides alternative and/or further features of the disclosure:

1. A device for reducing noise caused by a transformer, including:
at least one sound-reducing element including at least one duct arranged in a meandering pattern and configured to attenuate one or more soundwaves received from the transformer, the at least one sound-reducing element optionally being configured to be arranged on an exterior and/or an interior of the transformer.

2. The device according to aspect 1, wherein the at least one duct includes at least one inlet opening which faces the transformer, when the at least one sound-reducing element is arranged on the exterior of the transformer, wherein the at least one inlet opening is configured to receive one or more soundwaves from the transformer.

3. The device according to aspect 1 or 2, wherein the at least one duct includes a closed end.

4. The device according to any of the preceding aspects, wherein the at least one sound-reducing element includes a plurality of walls which at least partially define the at least one duct, in particular between opposing walls of the plurality of walls.

5. The device according to aspect 4, wherein at least some of the walls are arranged substantially parallel to each other.

6. The device according to aspect 4 or 5, further including at least one connecting device which interconnects at least two of the walls, in particular at least two opposing walls of the plurality of walls, in particular wherein the at least one connecting device is configured as a spacer.

7. The device according to aspect 6, wherein the at least one connecting device extends substantially perpendicularly from the respective walls.

8. The device according to any of the preceding aspects, wherein the at least one duct includes a plurality of duct sections which are interconnected, wherein at least some, in particular all, of the duct sections extend substantially parallel to each other.

9. The device according to aspect 8, wherein at least some, in particular all, of the duct sections are arranged such that the one or more soundwaves are redirected from an upstream duct section of the duct sections to a downstream duct section of the duct sections by at least one angle of redirection.

10. The device according to aspect 9, wherein the angle of redirection is at least 30°, particularly at least 40°, more particularly at least 50°, more particularly at least 60°, more particularly at least 70°, more particularly at least 80°, more particularly at least 90°, more particularly at least 100°, more particularly at least 110°, more particularly at least 120°, more particularly at least 130°, more particularly at least 140°, more particularly at least 150°, more particularly at least 160°, more particularly at least 170°, more particularly at least 180°.

11. The device according to any of the preceding aspects, wherein the at least one sound-reducing element is configured to be coupled to at least one support structure which is configured to be arranged on the exterior of the transformer, in particular wherein the at least one support structure is configured to be coupled to an outer surface of the transformer.

12. The device according to aspect 11, wherein the at least one support structure includes a plurality of channels, wherein at least one, in particular each, of the at least one sound-reducing element is arranged at least partially, in particular completely, within a channel of the plurality of channels.

13. The device according to aspect 12, wherein a cross-section of at least a portion of at least some, in particular each, of the channels is substantially completely filled by one or more of the at least one sound-reducing element.

14. The device according to aspect 12 or 13, wherein the channels are at least partially defined by a plurality of ribs which extend away from the transformer, when the at least one support structure is arranged on the exterior of the transformer, wherein the ribs are configured to conduct and dissipate heat from the transformer to an ambient.

15. The device according to any of aspects 12 to 14, wherein the channels each include at least one channel opening which faces towards the transformer, when the at least one support structure is arranged on the exterior of the transformer, wherein the at least one channel opening is substantially closed by one or more of the at least one sound-reducing element.

16. The device according to any of the preceding aspects, wherein the at least one duct is at least partially filled with at least one sound-absorbing material, in particular wherein the at least one sound-absorbing material is arranged proximate to the at least one inlet opening.

17. The device according to any of the preceding aspects, wherein a total length and/or a width of the at least one duct is sized based at least partially on at least one wavelength and/or at least one amplitude and/or at least one frequency, in particular one or more dominant frequencies of a plurality of frequencies, of the one or more soundwaves which are emitted by the transformer.

18. The device according to any of the preceding aspects, wherein a total length of the at least one duct is from 10% to 50%, in particular from 15% to 45%, in particular from 20% to 40%, in particular from 20% to 35%, in particular from 20% to 30%, in particular substantially 25%, of a wavelength of one or more soundwaves which are emitted by the transformer, in particular at least for a frequency of the one or more soundwaves of 300 Hz.

19. The device according to any of the preceding aspects, wherein the at least one sound-reducing element is integrally formed.

20. The device according to any of the preceding aspects, wherein the at least one sound-reducing element is made of at least one of the following materials: acrylonitrile styrene acrylate and a thermoplastic, in particular an amorphous thermoplastic.

21. The device according to any of the preceding aspects, wherein the at least one duct is configured to receive and interact with the one or more soundwaves from the transformer to reduce a sound pressure level of the transformer by at least 1 dB, particularly at least 2 dB, more particularly at least 3 dB, more particularly at least 4 dB, more particularly at least 5 dB, more particularly at least 6 dB, more particularly at least 7 dB, more particularly at least 8 dB, more particularly at least 9 dB, more particularly at least 10 dB.

22. A system including at least one transformer and at least one device according to any of the preceding aspects which is arranged on an exterior of the at least one transformer.

[0044] Fig. 1 schematically shows, in a top view, a device 10 for reducing noise caused by a transformer 12. For clarity purposes, not all of the elements shown in Fig. 1 are provided with reference signs, in particular when a plurality of the respective element are shown in Fig 1. The device 10 may include at least one support structure 14 configured to be arranged on an exterior of the transformer 12. The at least one support structure 14 may be mounted on an outer surface of the transformer 12, as shown in Fig. 1, or may be arranged at a distance from the transformer 12. Though only a single device 10 is shown in Fig. 1, a plurality of devices 10 may be provided. For instance, one or more devices 10 may be provided on a plurality, in particular all, sides of the transformer 12.

[0045] The device 10 may further include at least one sound-reducing element 16 configured for reducing noised caused/generated by the transformer 12. The at least one sound-reducing element 16 may be arranged at least partially within the at least one support structure 14. The at least one sound-reducing element 16 may be integrally formed. Alternatively, the at least one sound-reducing element 16 may be assembled from a plurality of components. Alternatively, the at least one support structure 14 may be omitted. For instance, the at least one sound-reducing element 16 may be mounted, e.g., directly, to at least one surface, preferably at least one external surface and/or at least one internal surface, of the transformer 12.

[0046] The at least one sound-reducing element 16 may include at least one duct 18. The at least one duct 18 may be arranged in a meandering pattern. The at least one duct 18 may be configured to receive one or more soundwaves from the transformer 12 to reduce noise caused by the transformer 12.

[0047] The device 10 may be used with any type of transformer to reduce noise caused by the respective transformer. For instance, the transformer 12 may be a liquid-immersed transformer, a dry-type transformer, or any other type of transformer. Thus, the device 10 disclosed herein is not limited to an application with one or more specific types of transformers. In general, the transformer 12 may include at least one receptacle or casing 20, at least one core 22, and at least one winding 24 wound at least partially about the at least one core 22. The device 10 may be mounted to the receptacle or casing 20, in particular to an outer surface thereof.

[0048] The at least one duct 18 may include at least one inlet opening 26 which faces the transformer 12, when the at least one support structure 14 is arranged on the exterior of the transformer 12. The at least one inlet opening 26 may be configured to receive one or more soundwaves from the transformer 12. The at least one duct 18 may include a closed end 28. The at least one sound-reducing element 16 may include a plurality of walls 30 which at least partially define the at least one duct 18, in particular between opposing walls 32 of the plurality of walls 30.

[0049] The device 10 may further include at least one connecting device 33 which interconnects at least two of the walls 30, in particular at least two opposing walls 32 of the plurality of walls 30. The at least one connecting device 33 may be configured as a spacer. The at least one connecting device 33 may be a solid piece of material. The at least one connecting device 33 is indicated in Fig. 1 as a dashed line to illustrate that the at least one connecting device 33 does not block the at least one duct 18 at the location of the at least one connecting device 33. Instead, the at least one connecting device 33 permits the one or more soundwaves and other media, such as air, to travel past the at least one connecting device 33, e.g., above and/or below, i.e., behind and/or in front of the drawing plane in Fig. 1, the at least one connecting device 33.

[0050] The at least one duct 18 may include a plurality of duct sections 34 which are interconnected. At least some, in particular all, of the duct sections 34 may extend substantially parallel to each other.

[0051] At least some, in particular all, of the duct sections 34 may be arranged such that the one or more soundwaves are redirected from an upstream duct section of the duct sections 34 to a downstream duct section of the duct sections 34 by at least one angle of redirection. As shown in Fig. 1, the angle of redirection may be substantially 180°. However, such an angle of redirection is only an exemplary configuration and may alternatively be a number of different values. In particular, the angle of redirection may be at least 30°, particularly at least 40°, more particularly at least 50°, more particularly at least 60°, more particularly at least 70°, more particularly at least 80°, more particularly at least 90°, more particularly at least 100°, more particularly at least 110°, more particularly at least 120°, more particularly at least 130°, more particularly at least 140°, more particularly at least 150°, more particularly at least 160°, more particularly at least 170°, more particularly at least 180°.

[0052] The at least one support structure 14 may include a plurality of channels 36. At least one, in particular each, of the at least one sound-reducing element 16 may be arranged at last partially, in particular completely, within a channel 36 of the plurality of channels 36.

[0053] A cross-section of at least a portion of at least some, in particular each, of the channels 36 may be substantially completely filled by one or more of the at least one sound-reducing element 16. The channels 36 may be at least partially defined by a plurality of ribs 40 which extend away from the transformer 12, when the at least one support structure 14 is arranged on the exterior of the transformer 12 in an operative state. The ribs 40 may be configured to conduct and dissipate heat from the transformer 12 to an ambient.

[0054] The at least one duct 18 may be at least partially filled with at least one sound-absorbing material. The at least one sound-absorbing material may be arranged proximate to the at least one inlet opening 26.

[0055] A total length and/or a width of the at least one duct 18 may be sized based at least partially on at least one wavelength, in particular one or more dominant frequencies of a plurality of frequencies, of the one or more soundwaves which are emitted by the transformer 12.

[0056] The orientation of the at least one sound-reducing element 16 shown in Fig. 1 is only exemplary. For instance, the at least one sound-reducing element 16 may be rotated, e.g., by 90°, compared with the orientation of the at least one sound-reducing element 16 shown in Fig. 1.

[0057] Figs. 2 and 3 show diagrams of a pressure distribution and a particle velocity distribution, respectively, in the at least one duct 18 of the at least one sound-reducing element 16. As can be seen in the diagram of Fig. 2, an acoustic pressure within the at least one duct 18 may increase further into the at least one duct 18. As can be seen in the diagram of Fig. 3, a particle velocity within the at least one duct 18 may be reduced further into the at least one duct 18, which may at least contribute to reducing noise caused by a transformer. For the results shown in Figs. 2 and 3, a sound-absorbing material was arranged at the at least one inlet opening 26.

Claims

1. A device (10) for reducing noise caused by a transformer (12), including:
   at least one sound-reducing element (16) configured to be arranged on an exterior of the transformer (12) and including at least one duct (18) arranged in a meandering pattern and configured to attenuate one or more soundwaves received from the transformer (12).

2. The device (10) according to claim 1, wherein the at least one duct (18) includes at least one inlet opening (26) which faces the transformer (12), when the at least one sound-reducing element (16) is arranged on the exterior of the transformer (12), wherein the at least one inlet opening (26) is configured to receive one or more soundwaves from the transformer (12).

3. The device (10) according to claim 1 or 2, wherein the at least one duct (18) includes a closed end (28).

4. The device (10) according to any of the preceding claims, wherein the at least one sound-reducing element (16) includes a plurality of walls (30) which at least partially define the at least one duct (18), in particular between opposing walls (32) of the plurality of walls (30).

5. The device (10) according to any of the preceding claims, wherein the at least one duct (18) includes a plurality of duct sections (34) which are interconnected, wherein at least some, in particular all, of the duct sections (34) extend substantially parallel to each other.

6. The device (10) according to claim 5, wherein at least some, in particular all, of the duct sections (34) are arranged such that the one or more soundwaves are redirected from an upstream duct section of the duct

sections (34) to a downstream duct section of the duct sections (34) by at least one angle of redirection.

7. The device (10) according to claim 6, wherein the angle of redirection is at least 30°, particularly at least 40°, more particularly at least 50°, more particularly at least 60°, more particularly at least 70°, more particularly at least 80°, more particularly at least 90°, more particularly at least 100°, more particularly at least 110°, more particularly at least 120°, more particularly at least 130°, more particularly at least 140°, more particularly at least 150°, more particularly at least 160°, more particularly at least 170°, more particularly at least 180°.

8. The device (10) according to any of the preceding claims, wherein the at least one sound-reducing element (16) is configured to be coupled to at least one support structure (14) which is configured to be arranged on the exterior of the transformer, in particular wherein the at least one support structure (14) is configured to be coupled to an outer surface of the transformer.

9. The device according to claim 8, wherein the at least one support structure (14) includes a plurality of channels (36), wherein at least one, in particular each, of the at least one sound-reducing element (16) is arranged at least partially, in particular completely, within a channel (36) of the plurality of channels (36).

10. The device (10) according to claim 9, wherein a cross-section of at least a portion of at least some, in particular each, of the channels (36) is substantially completely filled by one or more of the at least one sound-reducing element (16), in particular wherein the channels (36) are at least partially defined by a plurality of ribs (40) which extend away from the transformer (12), when the at least one support structure (14) is arranged on the exterior of the transformer (12), in particular wherein the ribs (40) are configured to conduct and dissipate heat from the transformer (12) to an ambient.

11. The device (10) according to any of the preceding claims, wherein the at least one duct (18) is at least partially filled with at least one sound-absorbing material, in particular wherein the at least one sound-absorbing material is arranged proximate to the at least one inlet opening (26).

12. The device (10) according to any of the preceding claims, wherein a total length and/or a width of the at least one duct (18) is sized based at least partially on at least one frequency, in particular one or more dominant frequencies of a plurality of frequencies, of the one or more soundwaves which are emitted by the transformer (12).

13. The device (10) according to any of the preceding claims, wherein a total length of the at least one duct (18) is from 10% to 50%, in particular from 15% to 45%, in particular from 20% to 40%, in particular from 20% to 35%, in particular from 20% to 30%, in particular substantially 25%, of a wavelength of one or more soundwaves which are emitted by the transformer (12), in particular at least for a frequency of the one or more soundwaves of 300 Hz.

14. The device (10) according to any of the preceding claims, wherein the at least one sound-reducing element (16) is integrally formed.

15. A system including at least one transformer (12) and at least one device (10) according to any of the preceding claims which is arranged on an exterior of the at least one transformer (12).

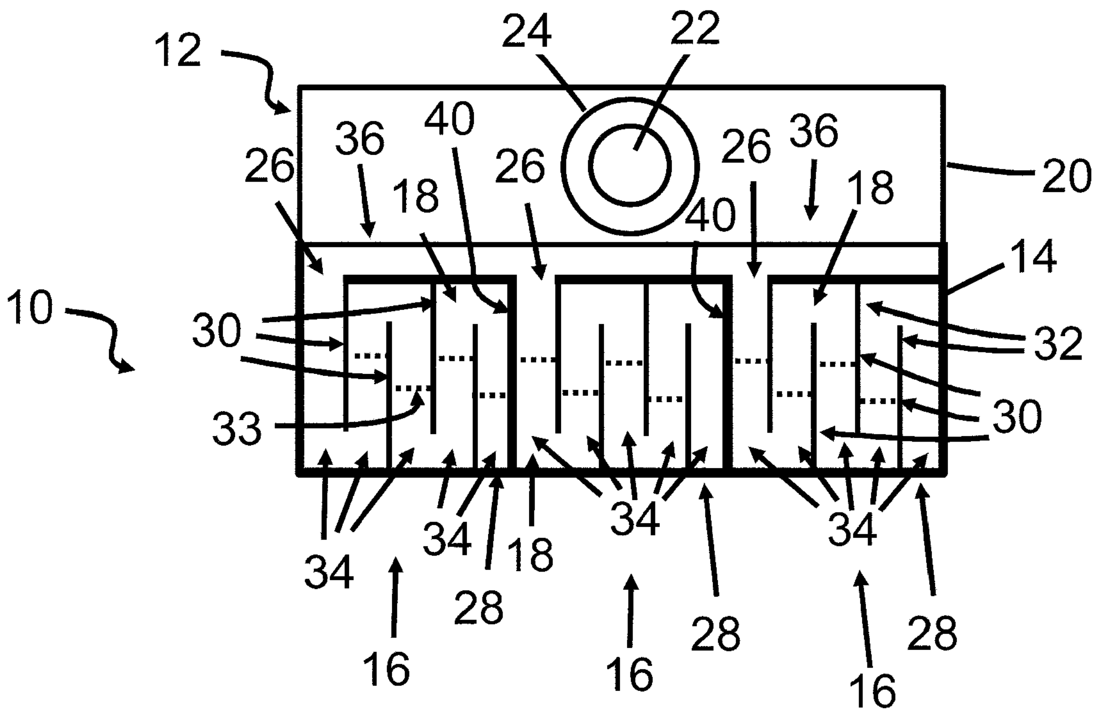

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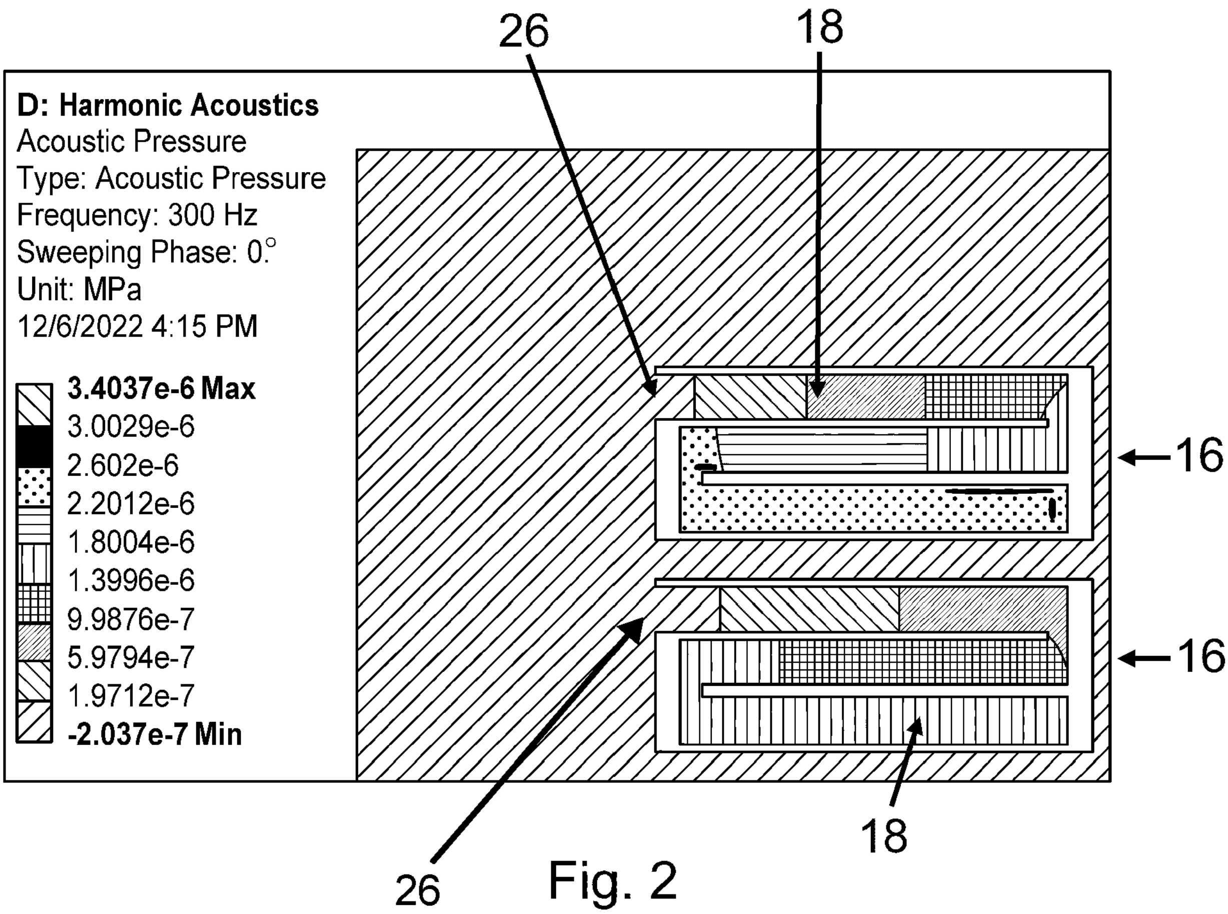
Fig. 1



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D: Harmonic Acoustics
Acoustic Pressure
Type: Acoustic Pressure
Frequency: 300 Hz
Sweeping Phase: 0.°
Unit: MPa
12/6/2022 4:15 PM
3.4037e-6 Max
3.0029e-6
2.602e-6
2.2012e-6
1.8004e-6
1.3996e-6
9.9876e-7
5.9794e-7
1.9712e-7
-2.037e-7 Min
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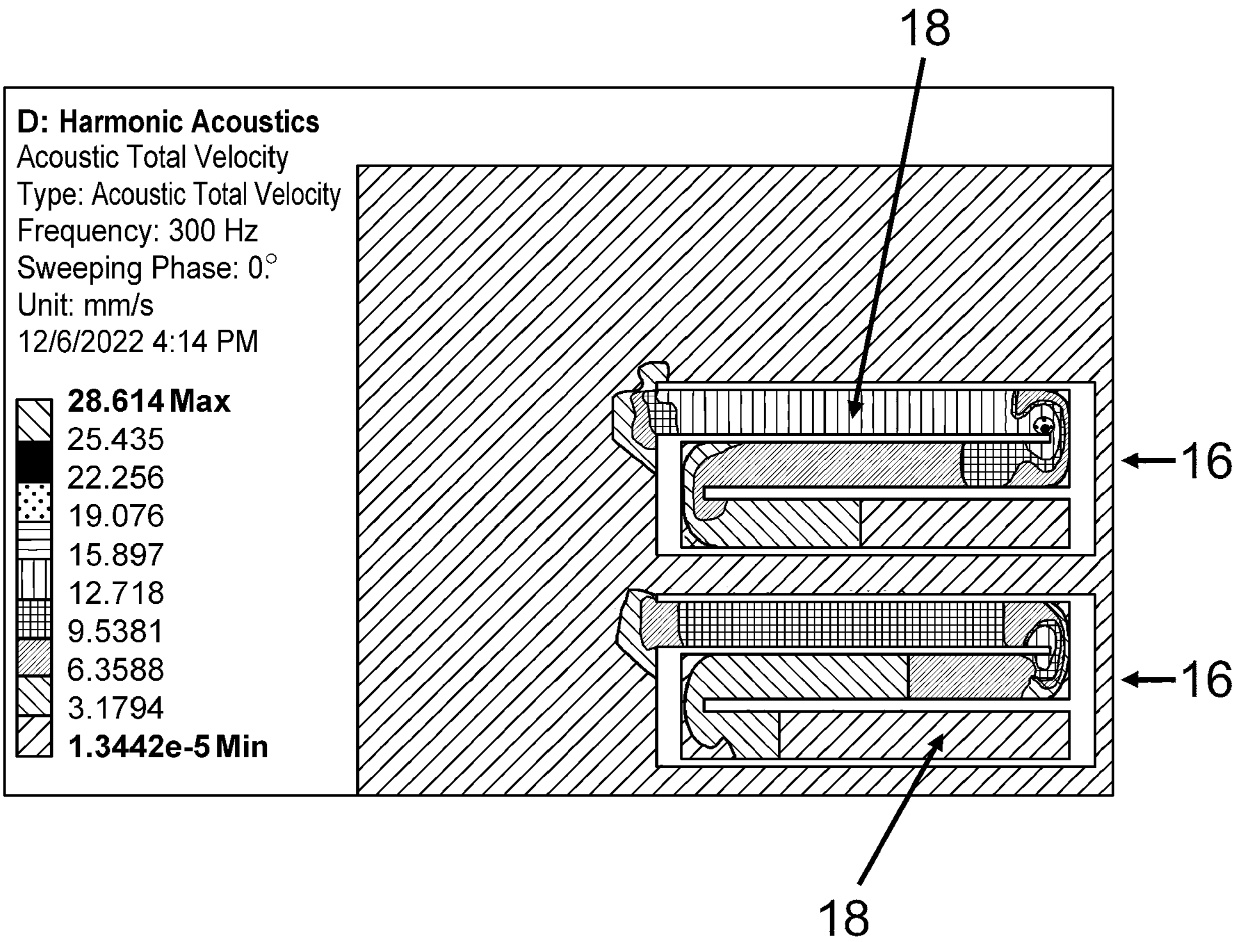
Fig. 2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D: Harmonic Acoustics
Acoustic Total Velocity
Type: Acoustic Total Velocity
Frequency: 300 Hz
Sweeping Phase: 0°
Unit: mm/s
12/6/2022 4:14 PM
28.614 Max
25.435
22.256
19.076
15.897
12.718
9.5381
6.3588
3.1794
1.3442e-5 Min
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Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 2659

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H01F
G10K

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	28 June 2023	Brächer, Thomas

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28-06-2023

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