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Description

The present invention relates to an electric motor used for railway vehicles such as the electric car, and more particularly, it relates to an air-cooled type induction motor capable of taking air into the motor to cool the motor.

Some of the air-cooled type motors are disclosed in a chapter titled "On The Induction Motor For Use With Vehicles" in the magazine "SCIENCE OF ELECTRIC CARS", February edition, 1988, pages 18 - 23, in published Unexamined Japanese Patent Application No. 61-94545, and also Utility Model Application No. 62-11371. As apparent from these references, the squirrel-cage type induction motor which can be controlled by VVVF inverters is now being used as the main motor for railway vehicles such as the electric train. The induction motor has no brushes. This enables the motor to require less maintenance, rotated at a higher speed, and made smaller in size, lighter in weight and larger in capacity.

The air-cooled squirrel-cage type induction motor includes a stator and a rotor. The stator includes stator core, coils and the like. The stator core is fixed to the inner circumference of the housing or frame of the motor. The stator coils are incorporated into inner circumferential portions of the stator core. Further, bearings for supporting the rotor in a smoothly rotatable state are arranged around the center of each of both end plates which form a part of the frame and which hold the rotor between them. The rotor includes a rotor shaft, a rotor core, a plurality of rotor bars, two end rings and the like. Both ends of the rotor shaft are supported rotatable by bearings. The rotor core is fixed to the rotor shaft. The plurality of rotor bars are incorporated into the outer circumferential portion of the rotor core. Both ends of each of these rotor bars are connected to the end rings.

In the case of the air-cooled motor having the above-described structure, a moving magnetic field is generated from the stator coils when current is supplied to them. When this moving magnetic field crosses the rotor bars, an electromotive force is derived. The rotor is rotated by interaction between the current and magnetic field generated.

In the case of this air-cooled motor, a large amount of heat is generated from the stator and the rotor when the motor is being rotated. When the stator coils and the rotor bars are heated by this heat to temperatures higher than predetermined ones, the insulating capacity of the stator coils is deteriorated while the strength of material of which the rotor bars are made is lowered. In order to prevent this, outside air is taken into the motor to cool its inside when it is being rotated.

This air-cooled motor is provided with an air inlet port at one end thereof in the axial line around which the stator is rotated. Further, an air outlet port is formed at the other end of the motor. Furthermore, a gap is formed between the stator core and the rotor core, and a plurality of ventilating holes are formed in the rotor core in the rotor, extending along the axial line around which the rotor core is rotated.

The induction motors of this kind are grouped into the ones of the forcedly-cooling type in which cooling air is forcibly fed from outside into the frame through the air inlet port, using a fan located outside the motor, and the ones of the induced type in which an impeller fixed to the rotor shaft is located in the frame and rotated together with the rotor to take the cooling air into the frame through the air inlet port.

The cooling air introduced into the frame is taken into one end of the stator core and blown out of the other end thereof, passing through the plurality of ventilating holes. This cooling air is finally exhausted outside the frame through the air outlet. The stator coils, the rotor bars and the like in the frame are cooled by the cooling air which passes through the frame.

The above-described induction motor is provided with a plurality of narrow ventilating holes through which the cooling air is circulated. Sound waves (or noise) having an uncertain frequency are generated by the cooling air thus circulated. The frequency of the sound waves changes as the rotation number of the motor is increased (the vehicle is accelerated) or decreased (the vehicle is decelerated). This noise is harsh to the ears of the human being and it makes passengers in the vehicle feel uncomfortable. When the motor is used for railway trains, for example, the noise is feared to cause a public nuisance to those people who live along the railroad. Further, in the case where the noise is increased when the motor comes to or near to its usually-used rotation number, the vehicles cannot be practically run on roads or railroads.

An object of the present invention is therefore to provide an induction motor capable of keeping noise low while it is being rotated.

Another object of the present invention is to provide an induction motor smaller in size but larger in output capacity.

A further object of the present invention is to provide an induction motor sufficiently resistant to vibration.

These objects are solved by an air-cooled type induction motor as claimed in claims 1 and 5.

According to the present invention, there can be provided an air-cooled type induction motor for use in vehicles comprising a cylindrical housing having an axis, an air inlet into which cooling air is supplied, and an air outlet which exhausts the cooling air, a stator for generating a magnetic field, the stator including an annular core coaxially fitted in the housing and located between the air inlet and the air outlet, and a plurality of stator coils having coil ends which extend from
the core to the air outlet and which face to the inner circumferential surface of the housing with a space therebetween, a rotor coaxially arranged inside the core with a predetermined gap through which the cooling air flows from the air inlet to the air outlet and rotatable about the axis of the housing, the rotor having a shaft coaxial with the axis of the housing, a plurality of ventilating holes extending through the rotor along the shaft and through which the cooling air flows from the air inlet to the air outlet, and a plurality of rotor bars extending along the shaft and to which current is supplied, and a sound insulating means for directing the cooling air flowing into the air outlet in a desired direction so as to decrease sound waves generated by circulation of the cooling air, the sound insulating means being arranged in the space between the coil ends of the stator coil and the inner circumferential surface of the housing, and being separated from the coil ends by a certain distance \( l' \), which is shorter than half the wavelength of the sound waves generated by the circulation of cooling air having such a frequency that depends upon the sum obtained by multiplying the number of the rotor bars by the rotation number of the rotor in one embodiment, and having a sound insulating portion having a predetermined length \( L_2 \) longer than the wavelength of the sound waves in another embodiment.

The noise which is generated by the air for cooling the induction motor and caused by the motor itself rotated at high speed can be thus eliminated.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1A shows a first example of the air-cooled induction motor according to the present invention sectioned along the rotor shaft of the induction motor and symmetrical relative to the axial line of the rotor shaft;

Fig. 1B is an enlarged partly-sectioned view showing a sound insulating plate and its adjacent area of the induction motor in Fig. 1A in more detail;

Fig. 2 is an enlarged partly-sectioned view showing a variation of the first air-cooled induction motor according to the present invention, in which a sound insulating plate and its adjacent area of the motor are shown in more detail;

Fig. 3A shows a part of a second example of the air-cooled induction motor according to the present invention sectioned along the rotor shaft of the motor and symmetrical relative to the axial line of the rotor shaft;

Fig. 3B shows a part of the second air-cooled inductor motor according to the present invention sectioned in a direction perpendicular to the rotor shaft of the motor;

Fig. 4 is a partly-sectioned view showing a variation of the second air-cooled inductor motor according to the present invention, in which the motor is sectioned in a direction perpendicular to its rotor shaft;

Fig. 5A shows a third example of the air-cooled induction motor according to the present invention sectioned along the rotor shaft of the motor and symmetrical relative to the axial line of the rotor shaft;

Fig. 5B shows a part of the induction motor in Fig. 5A sectioned in a direction perpendicular to the rotor shaft of the motor;

Fig. 5C is an enlarged partly-sectioned view intended to explain how noises can be reduced by the third air-cooled induction motor shown in Figs. 5A and 5B;

Fig. 6A shows a part of a variation of the third air-cooled induction motor sectioned along the rotor shaft of the motor and symmetrical relative to the axial line of the rotor shaft; and

Fig. 6B shows a part of the induction motor in Fig. 6A sectioned in a direction perpendicular to the rotor shaft of the motor.

Figs. 1A and 1B show a first example of the air-cooled squirrel-cage type induction motor according to the present invention. The squirrel-cage type induction motor 2 includes a cylindrical motor housing or frame 4 into which a stator 10 for generating a magnetic field is shrinkage-fitted and which is provided with a squirrel-cage type rotor 30 rotatably supported inside the stator 10. The stator 10 has stator coils 12 to which current is supplied to generate the magnetic field, and stator core 14 for supporting the stator coils 12. The cylindrical frame 4 has an air inlet port 4a, an end plate 8 at its one open end and another end plate 8 having an air outlet port 8a at its other open end along its axial line around which the rotor 30 is rotated. The stator core 14 is formed by stacking a large number of thin iron plates 16 one upon the other to each of which insulating matter is laminated. The stator core 14 is fixed to the inner circumference of the frame 4 by means of holder members 18. A plurality of slots 20, parallel to the shaft of the frame 4, are formed in the inner circumferential portion of the stator core 14. The stator coils 12 are incorporated into the slots 20 in the stator core 14. The stator coil 12 directs its one end 22 in a direction parallel to the axial direction in which the stator core 14 is rotated and its another end 24 in a direction reverse to that direction in which the one end 22 of the stator coil 12 is directed. Bearings 26 and 28 are located at center portions of the end plates 8 and 8 of the frame 4.

The squirrel-cage type rotor 30 includes a rotor or motor shaft 32 passing through its center, a rotor core 34 provided with a plurality of rotor bars 36 each formed by a copper band and arranged at a same interval, and two rotor holder members 38 for sandwiching the rotor core 34 between them. The rotor shaft 32 is smoothly rotatably supported by the bear-
ings 26 and 28 located at the center portions of the end plates 6 and 8. The rotor core 34 is formed by stacking a large number of thin iron plates 40 one upon the other to each of which insulating matter is laminated. The rotor core 34 is fixed to the rotor shaft 32 by the holder members 38. A plurality of slots 44 are formed in the outer circumferential portion of the rotor core 34. The rotor bars 36 are incorporated into the slots 44 of the rotor core 34. One end of each of the rotor bars 36 is directed in a direction parallel to the axial direction in which the rotor core 34 is rotated while the other end thereof is directed reverse to that direction in which the one end of the rotor bar 36 is directed. Both ends of each of the rotor bars 36 are connected to each other by short-circuit or end rings 46. A gap G is formed between the outer circumference of the rotor core 34 and the inner circumference of the stator core 14. A plurality of ventilating holes 48 extend along the axial line around which the rotor core 34 and its holder members 38 are rotated, passing through the rotor core 34 and its holder members 38.

The air-cooled induction motor 2 further includes, between the frame 4 and the stator coils 12, a sound insulating plate 50 for preventing sound waves from being amplified. The sound insulating plate 50 is made of a metallic or non-metallic material and formed like a ring, extending along the outer circumference of the stator coils 12 and in the circumferential direction of the frame 4. The sound insulating plate 50 has at one end thereof a flange 52, which is fitted into the inner circumference of the stator core holder member 18 and fixed between the frame 4 and the stator coils 12 by pressing the holder member 18 against one end face of the stator core 14. The sound insulating plate 50 is tapered, spreading more and more as it comes from its one end at which the flange 52 is formed nearer to its other open end 54, and it serves as a centrifugal fan for exhausting high pressure pulsating air current K, which is blown out of slit-shaped clearances at the stator coils 12, outside through its open end 54 as exhausted air current L when the rotor bars 36 are rotated at high speed.

It will be now studied how sound waves (or noise) S having a specific frequency are generated in the induction motor.

The both ends of each of the rotor bars 36 are projected from the both ends of the rotor core 34. When the rotor 30 is rotated, therefore, cooling wind H is sucked through the air inlet port 4a into the motor 2 and circulates toward the air outlet port 8a to generate wind I which has relatively high pressure. The high pressure wind I blows through the motor 2, as if it were a centrifugal fan, from the center of the rotor 30 or rotor shaft 32 in a direction or radial direction perpendicular to the shaft 32. Each of the rotor bars 36 has a relatively large thickness to create a sectional area necessary enough to serve as a copper conductor. It is therefore well-known that the high pressure wind I becomes pulsating air current J whose maximum value changes as time changes. It is also well-known that the vibration ν or frequency f of the pulsating air current J depends upon that product which is obtained by multiplying the number of the rotor bars 36 by the rotation number of the rotor 30. The stator coil 12, its copper wire occupying a large ratio of its sectional area, being curved to enter into a next slot and formed like a circumference in the stator 10, serves to exhaust the pulsating air current J, which is discharged through the rotor 30, in the outer circumferential direction of the motor 2 as high pressure pulsating air current K. The high pressure pulsating air current K is rapidly diffused in a hollow formed outside the stator coils 12 to generate sound waves S which cause noise. The high pressure pulsating air current K or sound waves S are reflected by the inner wall of the frame 4 and again returned back to those portions of the stator coils 12 where the high pressure pulsating air current K is exhausted. The high pressure pulsating air current K thus returned is again directed toward the frame 4 together with its following high pressure pulsating air current K and then reflected by the frame 4. The high pressure pulsating air current K is therefore reciprocated between the inner wall of the frame 4 and the outer circumferential portions of the stator coils 12. The inner wall of the frame 4 and the outer circumferential portions of the stator coils 12 cooperate this time to serve as if they were a resonance box. The sound waves (or noise) S generated by the high pressure pulsating air current K is thus gradually amplified to become noise which is uncomfortable to the ears of the human being. It has been confirmed by tests that this amplifying of the sound waves S is increased particularly at the time when the distance f of the inner wall of the frame 4 relative to the outer circumferential portion of the stator coils 12 is about 0.5 or 1 times the wavelength λ of the sound waves S. (The pulsating air current J, high pressure pulsating air current K and sound waves S cannot be distinguished from one another. Therefore, they are denoted by J(K) or K(S), for example, in the accompanying drawings).

The position of the sound insulating plate 50 to be located or the distance of the sound insulating plate 50 relative to the outer face of the stator coils 12 will now be studied. As described above, the sound waves (or noise) S is generated by the pulsating air current K and its frequency is defined by the product obtained by multiplying the number of the rotor bars 36 by the rotation number of the rotor 30. The frequency f of the sound waves S which are feared to become noise is therefore defined as follows: Assuming that the number of the rotor bars 36 is 26 (smallest in the case of the now-available induction motors) and that the rotation number of the rotor 30 is 3000 r.p.m. (smallest of those rotation numbers of the induction motor which make the human being hear noise),
Assuming that the number of the rotor bars 36 is 46 (common in the now-available inductor motors) and that the rotation number of the rotor 30 is 7000r.p.m. (largest in the now-available induction motors),

\[ f_u = 46 \times 7000 / 60 = 536 \text{Hz} \]

The most popular speed range in which the induction motor 2 is rotated is obtained when the rotor 30 is rotated at a speed of 5000r.p.m. When the number of the rotor bars 36 is 46, therefore,

\[ f_u = 46 \times 5000 / 60 = 3833 \text{Hz} \]

(subscripts L, U and N annexed in the above-cited equations denote the smallest rotation number of the rotor 30 which make the human being hear noise, the largest rotation number of the motor, and the most popular speed range in which the motor is rotated).

On the other hand, it has been confirmed by tests that the amplifying of the sound waves is increased to the greatest extent particularly at the time when the distance \( l \) between the inner wall of the frame 4 and the outer circumferential portion of the stator coils 12 is about 0.5 or 1 times the wavelength \( \lambda \) of the sound waves S. It is therefore preferable that the sound insulating plate 50 is located at a position where the distance \( l \) between the inner wall of the frame 4 and the outer circumferential portion of the stator coils 12 becomes smaller than 0.5 times or larger than 1 time the wavelength \( \lambda \) of the sound waves S. In other words, the sound insulating plate 50 is located at a position where a distance \( l \), measured from the outer face of the stator coils 12 is considerably smaller than half the wavelength \( \lambda \) of the sound waves S which has the frequency \( f \). (Numerals 1, 2 and 3 annexed in the following represent the first, second and third examples of the induction motor 2 according to the present invention).

Wavelength \( \lambda_u \) of the lowest frequency \( f_u \) relating to the sound waves S which are feared to become noise is as follows:

\[ \lambda_u = 330000 \text{ (mm/sec) / } 1300 \text{ (l/sec) = 254 mm} \]

Therefore, distance \( l_{uL} \) of the sound insulating plate 50 relative to the outer face of the stator coils 12 is preferably as follows:

\[ 254 \times 0.5 = 127 \text{mm > } l_{uL} \]

Wavelength \( \lambda_n \) of frequency \( f_n \) relating to the sound waves S which are created at the time when the motor is normally operated is as follows:

\[ \lambda_n = 330000 \text{ (mm/sec) / 3833 (l/sec) = 86.1 mm} \]

Therefore, distance \( l_{un} \) of the sound insulating plate 50 relative to the outer face of the stator coils 12 is more preferably defined as follows:

\[ 86.1 \times 0.5 = 43 \text{mm > } l_{un} \]

In addition, wavelength \( \lambda_u \) of the highest frequency \( f_u \) relating to the sound wave S which is created at the time when the rotation number of the rotor 30 is the largest is calculated as follows:

\[ \lambda_u = 330000 \text{ (mm/sec) / 5367 (l/sec) = 61.5 mm} \]

Therefore, distance \( l_{uu} \) of the sound insulating plate 50 relative to the outer face of the stator coils 12 is gained as follows:

\[ 61.5 \times 0.5 = 30 \text{mm > } l_{uu} \]

However, the distance \( l_{uu} \) of the sound insulating plate 50 relative to the outer face of the stator coil 12 when the frequency is the lowest \( f_u \) becomes about 2 times the distance \( l_{uu} \) of the sound insulating plate 50 and it is therefore feared that the noise S is increased at the time when the speed of the motor is in the low speed range. Therefore, the distance \( l \) of the sound insulating plate 50 relative to the outer face of the stator coils 12 is practically defined in such a way that the sound insulating plate 50 can function most effectively at the frequency \( f_u \) of the sound waves S which are generated at the time when the motor is normally operated. When the distance \( l \) becomes too short, it is feared that the sound insulating plate 50 prevents cooling or high pressure wind \( H \), which serves to cool the motor 2, from easily passing through the motor 2.

The distance \( l \) of the sound insulating plate 50 relative to the outer face of the stator coil 12 must be therefore kept longer than at least 10mm. It has been confirmed by results of various tests that the distance \( l \) is the optimum when it is in a range of 20 - 35mm.

This sound insulating plate 50 can prevent the sound waves S, which are generated when the rotor 30 is rotated, from being amplified. More specifically, when the rotor bars 36 are rotated and the high pressure pulsating air current \( K \) is thus generated, the air current \( K \) is introduced to the sound insulating plate 50, passing between the stator coils 12. This high pressure pulsating air current \( K \) is reflected by the sound insulating plate 50 which is separated from the outer face of the stator coils 12 by the distance \( l \). It is thus made different in phase from its following high pressure pulsating air currents which will be successively generated. When this pulsating air current \( K \) whose phase has been changed is struck against its following pulsating air current, the sound waves S can be prevented from being amplified.

The sound insulating plate 50 is tapered, spreading more and more from its flange 52 to its open end 54, and this enables the pulsating air current \( K \) to be more quickly exhausted from the air outlet port 8a, as exhausted current \( L \), along the tapered portion of the sound insulating plate 50.

The space between the stator coils 12 and the frame 4 is made narrower by the sound insulating plate 50 than in the case of the conventional motors. When the pulsating air current \( K \) is to be exhausted outside as the exhausted current \( L \), it passes through an inner of stator coils 12 to thereby cool the motor 2 to a greater extent.

Fig. 2 shows a variation of the sound insulating plate shown in Figs. 1A and 1B. The same components as those in Figs. 1A and 1B will be represented by the same reference numerals. According to this variation of the sound insulating plate, it is formed inte-
gral to one of the holder members or stator core holder members 60 which serve to fix the stator core 14 to the inner circumference of the frame 4. The core holder member 60 presses the stator core 14 inward by its one end while it allows the high pressure wind 1 blown through the gap G to be exhausted at an interval of the predetermined distance $l_1$. That end 62 of the core holder member 60 which is located opposite to the stator core 14 is bent to contact with and fix to the frame 4. Even when the rotor shaft 32 or rotor bars 36 rotates or the induction motor 2 vibrates, therefore, a rigid sound insulating plate which neither vibrates nor contacts the rotor 30 can be provided.

Figs. 3A and 3B show a second example of the air-cooled squirrel-cage type induction motor according to the present invention. The same components as those in Figs. 1A and 1B will be denoted by the same reference numerals.

According to this second example, sound wave induction plates 70 each being formed by a plurality of thin plates, having a relatively long length $l_2$ when it is developed, and serving to extinguish the sound waves (or noise) S generated by the rotating rotor 30, are arranged in a space defined by the stator coils 12 and the rotor 30 in the frame 4. The sound wave induction plates 70 are supported, directing in the same direction, by induction plate bosses 72, each of which is fixed to one of the stator holder member 18 at one end thereof, and they are assembled as a part of the frame 4 or integral to the frame 4 because their bosses 72 are fixed to the frame 4. That end of the sound wave induction plates 70, which are located opposite to its end fixed to the stator holder member 18, is provided with a stopper 74 for preventing each of the sound wave induction plates 70 to contact the others while vibrating. The sound wave induction plates 70 are incorporated into the induction plate bosses 72 and the stopper 74 which are two- or four-divided in a direction perpendicular to the rotor shaft 32. The sound wave induction plates 70 are arranged enclosing the rotor shaft 32 because the induction plate bosses 72 and the stoppers 74, each of which is two- or four-divided, are fixed to the frame 4 in the circumferential direction of the frame 4.

As already described above, the high pressure wind 1 is generated by the rotating rotor bars 36. The pulsating air current K is caused by the high pressure wind 1 which passes through the stator coils 12. The pulsating air current K is introduced into cooling wind passages 76 formed by the sound wave induction plates 70, guided along the curved passages 76 and discharged, as the discharged air current L, into the gap G between the frame 4 and the sound wave induction plates 70. However, a part of the pulsating air current K is reflected by the inner circumference of the frame 4 and is again introduced to the rotor shaft 32. When each of the passages 76 and the gap G are sufficiently large (or wide) in this case, it is well known that the sound waves (or noise) S kill one another to become reduced to a greater extent because the pressure of the pulsating air current K (or sound waves S) is reduced or pressure directed in the reverse direction is generated. When the passages 76 and the gap G are not large (or wide) enough or none of the passages 76 and the gap G are present, the pulsating air current K (or sound waves S which are uncomfortable to the ears of the human being) is introduced, as it is, to the rotor shaft 32.

Because the sound wave induction plates 70 is shaped like a spiral, the passages 76 and the gap G can be kept sufficiently large or wide. As already described above, the distance $l_2$ between the inner wall of the frame 4 and the outer circumference portion of the stator coils 12 which are feared to form a resonance box can be made sufficiently long relative to the wavelength of the sound waves S which are suspected to originate noise. The amplifying of the sound waves S is increased particularly when the distance becomes about 0.5 or 1 times the wavelength $\lambda$ of the sound waves S. The distance $l_2$ is therefore made sufficiently larger than 1 times the wavelength $\lambda$ of the sound waves S which has such frequency that causes noise. This prevents the pulsating air current K (or sound waves S), which has been reflected by the inner wall of the frame 4, from being amplified and the occurrence of the noise S which is uncomfortable to the ears of the human being can be thus prevented.

When the passages 76 and the gap G are made sufficiently large (or wide), it is feared that the pulsating air current K (or sound waves S) is amplified at the time when the motor 2 is rotated at a relatively low speed. When the motor 2 is rotated at a relatively low speed, however, the pressure of the pulsating air current K itself which causes such sound waves that are heard as noise to the ears of the human being becomes relatively small. The time during which the motor 2 is rotated at low speed corresponds to those time periods during which the vehicle is accelerated and decelerated, and these time periods occur only a little part of that time during which the vehicle is being driven. It hardly happens therefore that the human being feels the sound waves as noise.

Fig. 4 shows a variation of the sound wave induction plates. According to this variation, sound insulating plates 80 are shaped like a reversed L (it may be expressed that the plates 80 are shaped like an L depending upon the direction in which their section is viewed) when they are sectioned in a direction perpendicular to the rotor shaft 32. In these sound insulating plates 80, the distance $l_2$ can be made sufficiently long relative to the wavelength $\lambda$ of the sound waves S which are feared to originate noise.

Figs. 5A and 5B show a third example of the air-cooled squirrel-cage type induction motor according to the present invention. The same components as those in Figs. 1A and 1B will be denoted by the same...
reference numerals.

According to this third example, sound wave induction blocks 90 which serve to extinguish the sound waves (or noise) \( S \) generated by the rotating rotor 30 are formed in the space between the stator coils 12 and the frame 4. Each of the sound wave induction blocks 90 is formed by piling plural cylindrical or polygonal hollow pipes in a plurality of layers in a direction perpendicular to the rotor bar 36 (or in the circumferential direction of the motor 2), and their lengths \( \ell_{92}, \ell_{94}, \ell_{96} \) and \( \ell_{98} \) are different for every layer (numerals 92, 94, 96 and 98 annexed denote the layers of the pipes).

According to this sound wave induction blocks 90, the cooling wind \( I \) or high pressure pulsating air current \( K \) blown from the rotor 30 to the stator 10 is introduced into the pipes in the layers 92, 94, 96 and 98 of the blocks 90. The pipes in one layer are different in length from those in the other layers. Therefore, the pulsating air current \( K \) is exhausted as the exhausted air current \( \ell \) after it is divided by the pipes in the layers 92, 94, 96, and 98, and its time needed to pass through them is changed by them. As apparent from Fig. 5C, the pulsating air current \( K \) which has passed through the pipes in the layers 92 - 98 is exhausted under the state that it is dispersed. The distance between the inner wall of the frame 4 and the outer circumferential portion of the stator coils 12 which serves to act as the resonance box can be thus changed at random relative to the wavelength of the sound waves \( S \) which are supposed to generate noise. In other words, the amplifying of the sound waves \( S \) comes to its peak particularly at the time when the distance \( \ell \) is about 0.5 or 1 times the wavelength \( \lambda \) of the sound waves \( S \). When the lengths of the pipes in the layers 92 - 98 are made shorter than 0.5 times and/or longer than 1 time the wavelength \( \lambda \) of the sound waves \( S \), therefore, the noise \( S \) which is uncomfortable to the ears of the human being can be prevented from being caused.

Fig. 6A and 6B show a variation of the third example according to the present invention. Each of sound insulating blocks 100 includes a plurality of sound insulating plates 102, 104, 106 and 108 having lengths \( \ell_{102} \) (not seen in Fig. 6B), \( \ell_{104}, \ell_{106} \) and \( \ell_{108} \) different in a direction perpendicular to the rotor bar 36 (or in the circumferential direction of the frame 4), and also having widths \( W_{102}, W_{104}, W_{106} \) and \( W_{108} \) different in a direction parallel to the rotor bar 36 (or in the axial direction of the frame 4). The cooling wind \( I \) or high pressure pulsating air current \( K \) blown from the rotor 30 to the stator 10 is introduced to the sound insulating plates 102 - 108 which have different lengths and widths and whose lengths and widths are made shorter than 0.5 times and/or longer than 1 time the wavelength \( \lambda \) of the sound wave \( S \) generated by the pulsating air current. The high pressure pulsating air current \( K \) introduced to the sound insulating plates 102 - 108 is exhausted to different positions both in the circumferential and axial directions of the motor 2. This prevents the pulsating air current \( K \) (or sound wave \( S \)) from being amplified, so that the occurrence of the noise \( S \) uncomfortable to the ears of the human being can be prevented.

Claims

1. An air-cooled type induction motor for use in vehicles, comprising:

   cylindrical housing means (4) having an axis, an air inlet (4a) into which cooling air is supplied, and an air outlet (8a) through which the cooling air is exhausted;

   stator means (10) including a stator core (14) and stator coils (12), for generating a predetermined magnetic field, said stator means (10) being fixed to an inner wall of the housing means (4) having the air inlet (4a) and the air outlet (8a); and

   rotor means (30) including rotor bars (36), a plurality of ventilating holes (48), and a rotor core (34) which extends along a shaft (32), said rotor means (30) being provided inside said stator means (10) so as to be rotatable and coaxial with said stator means (10), with a predetermined gap (G) between said rotor means (30) and said stator means (10);

   characterized by further comprising:

   sound insulating means (50), arranged in a space between the housing (4) and stator coil ends (24) of said stator coils (12), for reducing sound waves which are generated when cooling air (I, K, J, L) supplied through the air inlet (4a) and flowing toward the air outlet (8a) through the gap (G) and the ventilating holes (48), passes between the housing (4) and the coil ends (24); the sound waves having a wavelength determined by the number \( B \) of the rotor bars (36) and rotational speed \( N \) of said rotor means (30); and wherein said sound insulating means (50) is separated from the coil ends (24) by a distance \( \ell_{1} \) which is shorter than half the wavelength of the sound waves.

2. The induction motor according to claim 1, characterized in that said sound insulating means (50) is slightly tapered as it extends from said rotor (30) nearer to said housing (4).

3. The induction motor according to claim 1, characterized in that said sound insulating means (50) has a substantially U-shaped section when it is sectioned in a direction parallel to the axis, and it is arranged like a circumference along the inner circumference of said housing (4).
4. The induction motor according to claim 1, characterized in that the distance \( \ell \) between the coil ends (24) and sound insulating means (50) is defined as follows:

\[
\ell < \frac{60 \times V}{2 \times N-B}
\]

in which \( V \) denotes the speed (mm/sec) of the sound wave advancing in the air, \( N \) denotes the rotation number (r.p.m.) of said rotor (30) and \( B \) denotes the number of the rotor bars (36).

5. An air-cooled type induction motor for use in vehicles, comprising:

- cylindrical housing means (4) having an axis, an air inlet (4a) into which cooling air is supplied, and an air outlet (8a) through which the cooling air is exhausted;
- stator means (10) including a stator core (14) and stator coils (12), for generating a predetermined magnetic field, said stator means (10) being fixed to an inner wall of the housing means (4) having the air inlet (4a) and the air outlet (8a); and
- rotor means (30) including rotor bars (36), a plurality of ventilating holes (48), and a rotor core (34) which extends along a shaft (32), said rotor means (30) being provided inside said stator means (10) so as to be rotatable and coaxial with said stator means (10), with a predetermined gap (G) between said rotor means (30) and said stator means (10); characterized by further comprising:

- sound insulating means (70, 90, 100), arranged in a space between the housing (4) and stator coil ends (24) of said stator coils (12), for reducing sound waves which are generated when cooling air (I, K, J, L) supplied through the air inlet (4a) and flowing toward the air outlet (8a) through the gap (G) and the ventilating holes (48), passes between the housing (4) and the coil ends (24); the sound waves having a wavelength determined by the number B of the rotor bars (36) and rotational speed N of said rotor means (30); and wherein said sound insulating means (70, 90, 100) has a sound insulating portion having a predetermined length \( \ell_x \) which is longer than the wavelength of the sound waves.

6. The motor according to claim 5, characterized in that said sound insulating means (70) has a fin-shaped cross section, and is longer than a wavelength of the sound waves.

7. The motor according to claim 5, characterized in that said sound insulating means (90) includes a plurality of pipes (92, 94, 96, 98) having different lengths, and said plurality of pipes are arranged such that the shortest pipe (92) is located closest to the shaft (32), and the longest pipe (98) is located closest to the housing.

8. The motor according to claim 5, characterized in that said sound insulating means (100) includes a plurality of waveguide plates (102, 104, 106, 108) having different lengths and cross-sectional areas, and said plurality of waveguide plates are arranged such that a plate (102) which is shortest and which has the smallest cross-sectional area is located closest to the shaft (32), and a plate (108) which is longest and which has the largest cross-sectional area is located closest to the housing.

9. The induction motor according to claim 6, characterized in that each of said sound insulating means (70) is shaped radial relative to the rotor shaft when it is sectioned in the circumferential direction, and they are formed like a spiral round the rotor shaft.

10. The induction motor according to claim 9, characterized in that: at least a part of each of said sound insulating means (70) is folded.

11. The induction motor according to claim 6, characterized in that the length K of said sound insulating means (70) sectioned and developed in the circumferential direction is defined as follows:

\[
K > \frac{60 \times V}{(N-B)}
\]

in which \( V \) denotes the speed (mm/sec) of the sound wave advancing in the air, \( N \) denotes the rotation number (r.p.m.) of said rotor (30) and \( B \) denotes the number of the rotor bars (36).

12. The induction motor according to claim 5, characterized in that said sound insulating means (90) includes pipes (92, 94, 96, 98) each of which is shaped cylindrical or polygonal in section when it is sectioned in the axial direction.

13. The induction motor according to claim 12, characterized in that the pipes (92, 94, 96, 98) are shaped like a honeycomb in section when it is sectioned in the axial direction.

14. The induction motor according to claim 5, characterized in that a piece of waveguide plate (102) which has the shortest length in the direction parallel to the axis is positioned nearest to said rotor and a waveguide plate which has the length K defined by

\[
K < \frac{60 \times V}{(N-B)}
\]

in which \( V \) denotes the speed (mm/sec) of the sound wave advancing in the air, \( N \) denotes the rotation number (r.p.m.) of said rotor (30) and \( B \) denotes the number of the rotor bars (36), and which has the shortest length in the direction cir-
circular to the axis is positioned nearest to the axis.

15. The induction motor according to claim 8, characterized in that a piece of waveguide plate (108) which has the longest length in the direction parallel to the axis is positioned nearest to said housing and a waveguide plate which has the length \( K \) defined by

\[
K > 60 \times V / (N \cdot B)
\]

in which \( V \) denotes the speed (mm/sec) of the sound wave advancing in the air, \( N \) denotes the rotation number (r.p.m.) of said rotor (30) and \( B \) denotes the number of the rotor bars (36), and which has the longest length in the direction perpendicular to the axis is positioned nearest to said housing.

**Patentansprüche**

1. Luftgekühlter Induktionsmotor zur Verwendung in Fahrzeugen, umfassend:
   - eine zylindrische Gehäuseeinhheit (4) mit einer Achse, einem Luftinlaß (4a), in den Kühl- luft eingespeist wird, und einem Luftauslaß (8a), über den die Kühl- luft abgeleitet wird,
   - eine Statoreinheit (10) mit einem Stator- kern (14) und Statorwicklungen (12) zum Erzeu- gen eines vorbestimmten Magnetfelds, wobei die Statoreinheit (10) an einer Innenwende der den Lufteinlaß (4a) und den Luftauslaß (8a) aufwei- senden Gehäuseeinhheit (4) befestigt ist, und
   - eine Läufereinheit (30) mit Läuferstäben (36), einer Anzahl von Belüftungsöffnungen (48) und einem Läuferkern (34), der sich längs einer Welle (32) erstreckt, wobei die Läufereinheit (30) innerhalb der Statoreinheit (10) drehbar und zu letzterer koaxial angeordnet ist und wobei ein vorbestimmter Spalt (G) zwischen Läufereinheit (30) und Statoreinheit (10) festgelegt ist,
   - ferner gekennzeichnet durch ein in einem Raum zwischen dem Gehäu- se (4) und Statorwicklungsplatten (24) der Stator- wicklungen (12) angeordneten Schallisoliermittel (50) zum Reduzieren bzw. Unterdrücken von Schallwellen, die erzeugt werden, wenn über den Lufteinlaß (4a) zugeleitet und durch den Spalt (G) sowie die Belüftungsöffnungen (48) zum Luftauslaß (8a) strömende Kühl- luft (I, K, J, L) zwischen dem Gehäuse (4) und den Wicklungs- platten (24) hindurchströmt, welche Schallwellen eine durch die Zahl B der Läuferstäbe (36) und die Drehzahl \( N \) der Läufereinheit (30) bestimmte Wellenlänge besitzen, und wobei das Schallisoli- tiermittel (50) von den Wicklungsplatten (24) um einen Abstand \( l_1 \) getrennt ist, der kürzer ist als die halbe Wellenlänge der Schallwellen.

2. Induktionsmotor nach Anspruch 1, dadurch gekennzeichnet, daß das Schallisoliermittel (50) in seiner Erstreckung vom Läufer (30) zum Gehäu- se (4) hin leicht verjüngt oder konisch ist.

3. Induktionsmotor nach Anspruch 1, dadurch gekennzeichnet, daß das Schallisoliermittel (50) im Schnitt in einer Richtung parallel zur Achse einen im wesentlichen U-förmigen Querschnitt aufweist und mantelförmig längs des Innenumfanges des Gehäuses (4) angeordnet ist.

4. Induktionsmotor nach Anspruch 1, dadurch gekennzeichnet, daß der Abstand 1 zwischen den Wicklungsplatten (24) und dem Schallisoliermittel (50) wie folgt definiert ist:

\[
1 < 60 \times V / (2 \times N \cdot B)
\]

worin bedeuten: \( V = \) Geschwindigkeit (mm/sec) der sich in der Luft fort- pflanzenden Schallwelle; \( N = \) Drehzahl (1/min) des Läufers (30); und \( B = \frac{\text{Zahl der Läuferstäbe}}{36} \).

5. Luftgekühlter Induktionsmotor zur Verwendung in Fahrzeugen, umfassend:
   - eine zylindrische Gehäuseeinhheit (4) mit einer Achse, einem Luftinlaß (4a), in den Kühl- luft eingespeist wird, und einem Luftauslaß (8a), über den die Kühl- luft abgeleitet wird,
   - eine Statoreinheit (10) mit einem Stator- kern (14) und Statorwicklungen (12) zum Erzeu- gen eines vorbestimmten Magnetfelds, wobei die Statoreinheit (10) an einer Innenwende der den Lufteinlaß (4a) und den Luftauslaß (8a) aufwei- senden Gehäuseeinhheit (4) befestigt ist, und
   - eine Läufereinheit (30) mit Läuferstäben (36), einer Anzahl von Belüftungsöffnungen (48) und einem Läuferkern (34), der sich längs einer Welle (32) erstreckt, wobei die Läufereinheit (30) innerhalb der Statoreinheit (10) drehbar und zu letzterer koaxial angeordnet ist und wobei ein vorbestimmter Spalt (G) zwischen Läufereinheit (30) und Statoreinheit (10) festgelegt ist,
   - ferner gekennzeichnet durch ein in einem Raum zwischen dem Gehäu- se (4) und Statorwicklungsplatten (24) der Stator- wicklungen (12) angeordnetes Schallisoliermittel (50) zum Reduzieren bzw. Unterdrücken von Schallwellen, die erzeugt werden, wenn über den Lufteinlaß (4a) zugeleitet und durch den Spalt (G) sowie die Belüftungsöffnungen (48) zum Luftauslaß (8a) strömende Kühl- luft (I, K, J, L) zwischen dem Gehäuse (4) und den Wicklungs- platten (24) hindurchströmt, welche Schallwellen eine durch die Zahl B der Läuferstäbe (36) und die Drehzahl \( N \) der Läufereinheit (30) bestimmte Wellenlänge besitzen, und wobei das Schallisoli- tiermittel (50) von den Wicklungsplatten (24) um einen Abstand \( l_1 \) getrennt ist, der kürzer ist als die halbe Wellenlänge der Schallwellen.
größer ist als die Wellenlänge der Schallwellen, aufweist.

6. Motor nach Anspruch 5, dadurch gekennzeichnet, daß das Schallisoliermittel (70) einen rippenartigen Querschnitt aufweist und länger ist als eine Wellenlänge der Schallwellen.

7. Motor nach Anspruch 5, dadurch gekennzeichnet, daß das Schallisoliermittel (90) eine Anzahl von Rohren (92, 94, 96, 98) verschiedener Längen aufweist und die zahlreichen Rohre so angeordnet sind, daß das kürzeste Rohr (92) der Welle (32) und das längste Rohr (98) dem Gehäuse am nächsten gelegen sind.

8. Motor nach Anspruch 5, dadurch gekennzeichnet, daß das Schallisoliermittel (100) eine Anzahl von Wellenleiterplatten (102, 104, 106, 108) verschiedener Längen und Querschnittsflächen aufweist und die zahlreichen Wellenleiterplatten so angeordnet sind, daß eine Platte (102), die am kürzesten ist und die kleinste Querschnittsfläche aufweist, der Welle (32) am nächsten gelegen ist, während eine Platte (108), die am längsten ist und die größte Querschnittsfläche aufweist, dem Gehäuse am nächsten gelegen angeordnet ist.

9. Induktionsmotor nach Anspruch 6, dadurch gekennzeichnet, daß jedes der Schallisoliermittel (70) radial relativ zur Läuferwelle geformt ist, wenn es in der Umfangsrichtung geschritten ist, und diese Mittel wie eine Spirale um die Läuferwelle herum geformt sind.

10. Induktionsmotor nach Anspruch 9, dadurch gekennzeichnet, daß mindestens ein Teil jedes der Schallisoliermittel (70) gefaltet bzw. umgebogen ist.

11. Induktionsmotor nach Anspruch 6, dadurch gekennzeichnet, daß die Länge K des Schallisoliermittels (70), in der Umfangsrichtung geschnitten und abgewickelt, wie folgt definiert ist:
   
   \[ K > 60 \times \frac{V}{(N \cdot B)} \]
   
   worin bedeuten: \( V \) = Geschwindigkeit (mm/s) der sich in der Luft fortpflanzenden Schallwelle; \( N \) = Drehzahl (1/min) des Läufers (30); und \( B \) = Zahl der Läuferstäbe (36).

12. Induktionsmotor nach Anspruch 5, dadurch gekennzeichnet, daß das Schallisoliermittel (90) Rohre (92, 94, 96, 98) umfaßt, die jeweils im Schnitt in der Achsrichtung mit einem zylindrischen oder mehlzackigen Querschnitt geformt sind.

13. Induktionsmotor nach Anspruch 12, dadurch gekennzeichnet, daß die Rohre (92, 94, 96, 98) im Schnitt in der Achsrichtung wabenförmig geformt sind.

14. Induktionsmotor nach Anspruch 8, dadurch gekennzeichnet, daß ein Stück einer Wellenleiterplatte (102), welche die kleinste Länge in der Richtung parallel zur Achse aufweist, dem Läufer am nächsten gelegen angeordnet ist, und eine Wellenleiterplatte mit der durch
   
   \[ K < 60 \times \frac{V}{(N \cdot B)} \]
   
   definierten Länge K (mit \( V = \) Geschwindigkeit (mm/s) der sich in der Luft fortpflanzenden Schallwelle; \( N = \) Drehzahl (1/min) des Läufers (30); und \( B = \) Zahl der Läuferstäbe (36)), und welche die kleinste Länge in der Richtung zirkular zur Achse bzw. um die Achse herum aufweist, der Achse am nächsten gelegen angeordnet ist.

15. Induktionsmotor nach Anspruch 8, dadurch gekennzeichnet, daß ein Stück einer Wellenleiterplatte (108), welche die kleinste Länge in der Richtung parallel zur Achse aufweist, dem Gehäuse am nächsten gelegen angeordnet ist, und eine Wellenleiterplatte mit der durch
   
   \[ K > 60 \times \frac{V}{(N \cdot B)} \]
   
   definierten Länge K (mit \( V = \) Geschwindigkeit (mm/s) der sich in der Luft fortpflanzenden Schallwelle; \( N = \) Drehzahl (1/min) des Läufers (30); und \( B = \) Zahl der Läuferstäbe (36)), und welche die größte Länge in der Richtung senkrecht zur Achse aufweist, dem Gehäuse am nächsten gelegen angeordnet ist.

**Reivendifications**

1. Moteur à induction du type refroidi à l‘air, destiné à être utilisé dans des véhicules, comprenant :
   - des moyens formant boîtier cylindrique (4) ayant un axe, une entrée d‘air (4a) dans laquelle on fournit de l‘air de refroidissement, et une sortie d‘air (8a) à travers laquelle on évacue l‘air de refroidissement ;
   - des moyens formant stator (10) comprenant un noyau de stator (14) et des bobines de stator (12), pour produire un champ magnétique prédéterminé, lesdits moyens formant stator (10) étant fixés à une paroi intérieure du boîtier (4) ayant l‘entrée d‘air (4a) et la sortie d‘air (8a) ; et
   - des moyens formant rotor (30) comprenant des barres de rotor (36), une pluralité de parois de ventilation (48), et un noyau de rotor (34) qui s‘étend le long d‘un arbre (32), ledit rotor (30) étant prévu à l‘intérieur dudit stator (10) de manière à être capable de tourner et étant coaxial au stator (10),
avec un intervalle prédéterminé (G) entre le dit rotor (30) et le dit stator (10) ;
- caractérisé en ce qu'il comprend en outre :
  - des moyens d'isolation sonore (50) agencés dans un espace entre le boîtier (4) et les extrémités (24) des bobines de stator (12), afin de réduire les ondes sonores qui sont produites lorsque l'air de refroidissement (I, K, J, L) fourni à travers l'entrée d'air (4a) et s'écoulant en direction de la sortie d'air (8a) à travers l'intervalle (G) et les parois de ventilation (48), passe entre le boîtier (4) et les extrémités (24) des bobines, les ondes sonores ayant une longueur d'onde déterminée par le nombre B des barres de rotor (36) et la vitesse de rotation N dit dit rotor (30), et en ce que les désits moyens d'isolation sonore (50) sont séparés des extrémités (24) des bobines d'une distance \( i \), qui est plus courte que la moitié de la longueur d'onde des ondes sonores.

2. Moteur à induction selon la revendication 1, caractérisé en ce que les désits moyens d'isolation (50) sont légèrement évacués tandis qu'ils s'étendent depuis le dit rotor (30) et en se rapprochant du dit boîtier (4).

3. Moteur à induction selon la revendication 1, caractérisé en ce que les désits moyens d'isolation sonore (50) ont une section sensiblement en forme de U lorsqu'ils sont en coupe dans une direction parallèle à l'axe, et en ce qu'ils sont agencés à la manière d'une circonférence le long de la circonférence intérieure dit dit boîtier (4).

4. Moteur à induction selon la revendication 1, caractérisé en ce que la distance \( i \) entre les extrémités (24) des bobines et les moyens d'isolation sonore (50) est définie comme suit :
\[
i < 60 \times V / (2 \times N \times B)
\]
dans laquelle \( V \) désigne la vitesse (mm/sec) des ondes sonores qui progressent dans l'air, \( N \) désigne la vitesse de rotation (rpm) dit dit rotor (30) et \( B \) désigne le nombre des barres de rotor (36).

5. Moteur à induction du type refroidi à l'air, destiné à être utilisé dans des véhicules, comprenant :
- des moyens formant boîtier cylindrique (4) ayant un axe, une entrée d'air (4a) dans laquelle on fournit de l'air de refroidissement, et une sortie d'air (8a) à travers laquelle on évacue l'air de refroidissement ;
- des moyens formant stator (10) comprenant un noyau dit stator (14) et des bobines de stator (12), pour produire un champ magnétique prédéterminé, les désits moyens formant stator (10) étant fixés à une paroi intérieure du boîtier (4) ayant l'entrée d'air (4a) et la sortie d'air (8a) ; et
- des moyens formant rotor (30) comprenant des barres de rotor (36), une pluralité de parois de ventilation (48), et un noyau de rotor (34) qui s'étend le long d'un arbre (32), dit dit rotor (30) étant prévu à l'intérieur dit dit stator (10) de manière à être capable de tourner et étant coaxial dit dit stator (10), avec un intervalle prédéterminé (G) entre dit dit rotor (30) et dit dit stator (10) ;
- caractérisé en ce qu'il comprend en outre :
  - des moyens d'isolation sonore (70, 90, 100) agencés dans un espace entre le boîtier (4) et des extrémités (24) des bobines de stator (12), pour réduire les ondes sonores qui sont produites lorsque l'air de refroidissement (I, K, J, L) fourni à travers l'entrée d'air (4a) et s'écoulant en direction de la sortie d'air (8a) à travers l'intervalle (G) et les parois de ventilation (48), passe entre le boîtier (4) et les extrémités (24) des bobines ; les ondes sonores ayant une longueur d'onde déterminée par le nombre B des barres de rotor (36) et la vitesse de rotation N dit dit rotor (30), et en ce que les désits moyens d'isolation sonore (70, 90, 100) comportent une partie d'isolation sonore ayant une longueur prédéterminée \( i_2 \) qui est plus longue que la longueur d'onde des ondes sonores.

6. Moteur selon la revendication 5, caractérisé en ce que les désits moyens d'isolation sonore (70) ont une section transversale en forme d'ailette, et en ce qu'ils sont plus longs que la longueur d'onde des ondes sonores.

7. Moteur selon la revendication 5, caractérisé en ce que les désits moyens d'isolation sonore (90) comprennent une pluralité de tubes (92, 94, 96, 98) ayant des longueurs différentes, et en ce que ladite pluralité de tubes sont agencées de telle manière que le tube le plus court (92) est situé le plus proche de l'arbre (32), et que le tube le plus long (98) est situé le plus proche du boîtier.

8. Moteur selon la revendication 5, caractérisé en ce que les désits moyens d'isolation sonore (100) comprennent une pluralité de plaques guide d'ondes (102, 104, 106, 108) ayant des longueurs différentes et des aires différentes en section transversale, et en ce que ladite pluralité de plaques guide d'ondes sont agencées de telle manière qu'une plaque (102) qui est la plus courte et qui a la plus petite aire en section est placée au plus proche de l'arbre (32), et qu'une plaque (108) qui est la plus longue et qui a la plus grande aire en
section est placée au plus proche du boîtier.

9. Moteur à induction selon la revendication 6, caractérisé en ce que chacun desdits moyens d’isolation sonore (70) est formé radialement par rapport à l’arbre de rotor lorsqu’il est en coupe dans la direction circonférentielle, et en ce qu’ils sont formés à la manière d’une spirale autour de l’arbre de rotor.

10. Moteur à induction selon la revendication 9, caractérisé en ce qu’au moins une partie de chacun desdits moyens d’isolation sonore (70) est repliée.

11. Moteur à induction selon la revendication 6, caractérisé en ce que la longueur K desdits moyens d’isolation sonore (70), en section et en développement dans la direction circonférentielle, est définie comme suit :

\[ K > 60 \times V/(N\times B) \]

dans laquelle V désigne la vitesse (mm/sec) des ondes sonores progressant dans l’air, N désigne la vitesse de rotation (tpm) dudit rotor (30) et B désigne le nombre de barres de rotor (36).

12. Moteur à induction selon la revendication 5, caractérisé en ce que lesdits moyens d’isolation sonore (90) comprennent des tubes (92, 94, 96, 98) qui ont chacun une forme cylindrique ou polygona le en coupe lorsqu’on les coupe dans la direction axiale.

13. Moteur à induction selon la revendication 12, caractérisé en ce que les tubes (92, 94, 96, 98) sont conformés à la manière d’un nid d’abeilles en coupe lorsqu’on les coupe dans la direction axiale.

14. Moteur à induction selon la revendication 8, caractérisé en ce qu’une pièce d’une plaque guide d’ondes (102), qui a la longueur la plus courte dans la direction parallèle à l’axe, est placée au plus proche dudit rotor ; et en ce qu’une plaque guide d’ondes qui a la longueur K définie par :

\[ K < 60 \times V/(N\times B) \]

dans laquelle V désigne la vitesse (mm/sec) des ondes sonores progressant dans l’air, N désigne la vitesse de rotation (tpm) dudit rotor (30) et B désigne le nombre des barres de rotor (36), et qui a la longueur la plus courte dans la direction circulaire par rapport à l’axe, est placée au plus proche de l’axe.

15. Moteur à induction selon la revendication 8, caractérisé en ce qu’une pièce d’une plaque guide d’ondes (108), qui a la longueur la plus longue dans la direction parallèle à l’axe, est placée au plus proche dudit boîtier ; et en ce qu’une plaque guide d’ondes qui a la longueur K définie par :

\[ K > 60 \times V/(N\times B) \]
dans laquelle V désigne la vitesse (mm/sec) des ondes sonores progressant dans l’air, N désigne la vitesse de rotation (tpm) dudit rotor (30) et B désigne le nombre des barres de rotor (36), et qui a la longueur la plus courte dans la direction perpendiculaire à l’axe, est placée au plus proche dudit boîtier.