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(71) Applicant: **Obschestvo s Ogranichennoi Otvetstvennostiu "Gella"**
Kazan, 420043 (RU)

(72) Inventors:
- **RAPPE, Mikhail Aituganovich**
  Kazan, 420061 (RU)
- **TITOV, Sergey Vladimirovich**
  Kazan, 420059 (RU)
- **VASILCHENKO, Evgenii Vasilievich**
  Kazan, 420078 (RU)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) WINCH FOR AUDIO EQUIPMENT AND SYSTEM CONTAINING SAME

(57) The invention relates to lifting devices for raising and lowering audio equipment. Technical result consists in providing a simple and reliable winch structure, increased service life of the winch and enhanced accuracy of audio equipment positioning. The technical result is achieved by a winch for audio equipment, comprising a cable and a housing that contains a drive and a drum, wherein a first part of the drum is designed for spooling a first portion of the cable, a second part of the drum is designed for spooling a second portion of the cable and presents a reel that has, disposed on the central bushing, a barrel for spooling the second cable portion, and two side plates, and an external annular wall is provided between the side plates of the reel, the diameter of the external annular wall being greater than that of the barrel of the reel; wherein one end of the first cable portion is designed to be connected to the audio equipment being suspended, and the second end of the first cable portion is fastened to the first part of the drum and connected to the second cable portion; one end of the second cable portion is connected to the first cable portion and is inserted into the reel, being fastened in the region of its annular wall, and the second end of the second cable portion is led out of the reel, being fastened in the region of the barrel of the reel, and is designed to be connected to an external signal path; wherein inner surface of the reel side plates is coated with a sliding material; the cable inside the reel has a coating that provides sliding of the cable relative to adjacent coils and relative to the sliding material covering the reel side plates.

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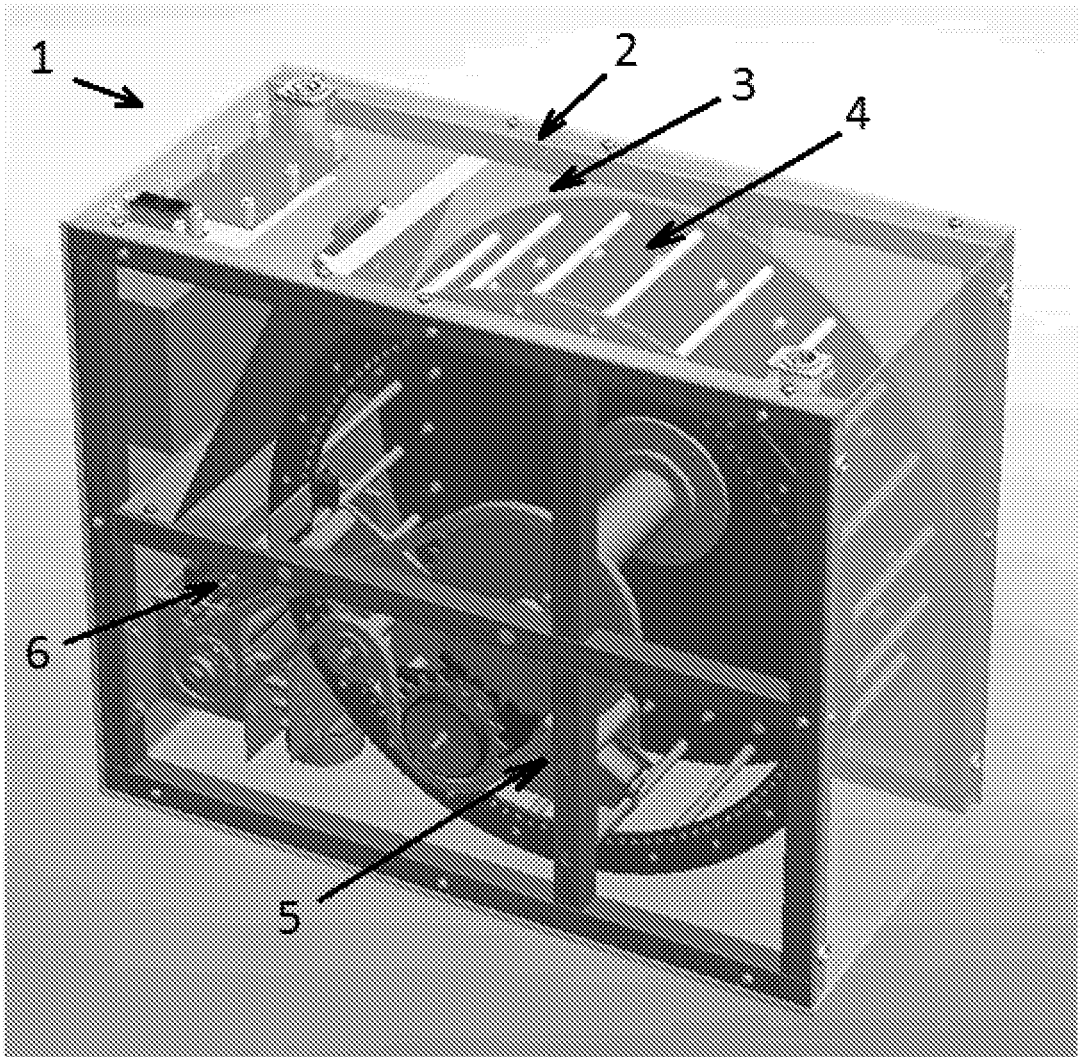


FIG. 2

Description

Field of the Invention

[0001] The invention relates to lifting devices for raising and lowering audio (acoustic) equipment in sound and recording systems used in concert halls, on theater stages, in conference rooms, studios, etc.

Description of the Prior Art

[0002] Currently, special-purpose microphone winches are widely used in concert halls and on theater stages to position, within the stage, audio equipment such as microphones that are used e.g. for recording audio during a concert.

[0003] The winches are installed on ceiling structures above the point where the microphone is to be fed to.

[0004] In conventional systems, when the microphone is raised, the excess cable is folded into a box or heaved up by moving apart rollers of the pulley block. Such systems are used quite rarely due to the design complexity and low reliability.

[0005] Also currently there are winches on the market, in which cable is laid on a stationary drum using a stacker that rotates around the drum. However, when winding or unwinding the cable, the hanging cable with the microphone twists, that is why the use of such winches is unacceptable or considerably limited.

[0006] There are also winches in which excess cable is spooled around a rotating drum. A problem of such winches deals with movement of the cable end secured to the movable drum. Traditionally, slip ring is used to overcome the problem. This solution is widely used in cable drums in various fields of art. However, this solution is hardly suitable for microphones. Moving contacts are a source of interference and distortion, even when they are at rest and have high quality contact sets.

[0007] Therefore, a solution that avoids breaking the circuit is preferable.

[0008] For example, a microphone winch is disclosed in US 5,526,997. The winch (Fig.1) comprises a housing that contains two reels, main and secondary, mounted on the same bushing having a hole extending therethrough from the main reel to the secondary reel. A signal cable is wound upon the two reels with a first end cable portion being coiled upon the main reel, an intermediate portion thereof extending through the hole formed in the common bushing member and a second end cable portion being coiled about the secondary reel. In the winch, the microphone is connected to the first cable portion. The second cable portion is shorter than the first one and includes an end that is attached to the housing to provide a stationary electrical connection with the path of audio recording equipment. By actuating the reels, the cable is wound on the reel or unwound from the reel, thereby positioning the microphone in vertical. With this arrangement, as the first cable portion is fully unwound from the main reel, the second cable portion is first unwound and then rewound onto the secondary reel. This solution connects the microphone to the audio recording equipment using a single continuous cable and avoids the use of slip rings to transfer signals between the microphone and audio recording equipment.

[0009] However, it should be noted that in practice it is not unusual that, during operation, it is necessary to periodically change the position of the suspended equipment, this resulting in occasional reversal of the reel rotation and change in the winding direction of the second cable portion. This applies especially to the situations where the equipment is suspended at a height of about half the permissible suspension height of the winch. In such scenarios, the most common arrangement of the second cable portion in the winch is that shown in Fig.1.

[0010] If this occurs, the transition zone from the intermediate cable portion passing through the hole in the bushing (i.e. approximately from the slot 80 in Fig.1) to the second cable portion during rotation of the reel experiences frequent serious bends and twists, while the remaining sections of the second cable portion, due to entanglement and formation of loops, can themselves both experience strong tension, and cause excessive tension in the same transition zone. That is, a relatively lower risk of damage to the cable exists only in the close to the extreme positions of the main part of the reel, either close to the fully unwound state, or close to the fully wound state, which prevents using the same winch in different stage configurations.

[0011] Moreover, in said winch, the compartment enclosing the second cable portion consists of a first wall that is stationary relative to the winch body, a second stationary wall and a movable bushing. The second wall is covered with a Teflon film, while the other parts are not. Taking into account that cables are traditionally produced with a PVC sheath, friction occurs in this compartment in the pairs cable-cable (PVC-PVC), cable-second wall (PVC-Teflon), and cable-first wall and cable-hub (for example, PVC-metal and/or PVC-plastic depending on the material of the bushing and first wall). The presence of moving and stationary parts in the said compartment and the effect of the different forces on the cable simultaneously from different sides during its movement inside the compartment can cause twisting and tension of the cable, its snagging and damage to the insulation, especially if there are roughness or burrs on the first wall and on the bushing.

[0012] All of these things provoke premature damage to the cable, introduction of interference and distortion, and, ultimately, breakage of the cable, which reduces the time of reliable and trouble-free operation of the winch.

[0013] Therefore, there is a need of measures to increase the reliability and durability of the equipment.

SUMMARY OF THE INVENTION

[0014] The present invention is intended to overcome

at least some of the above problems.

[0015] In a winch for audio equipment in accordance with the present invention, it is proposed to make walls of the compartment for the second cable portion completely movable relative to the winch body, to insert the cable into the compartment from the main part of the drum from the edge, rather than from the center, and, on the contrary, to draw the cable out from the compartment for connection with external equipment through the center of the compartment, and herewith to make all inner surfaces of the compartment sliding relative to each other.

[0016] In accordance with the invention, there is provided a winch for audio equipment, comprising a cable and a housing that contains:

- a drum designed for spooling the cable and comprising two parts disposed on a central bushing, wherein

  a first part of the drum is designed for spooling a first portion of the cable,
  a second part of the drum is designed for spooling a second portion of the cable and presents a compartment enclosing a reel that has, disposed on the central bushing, a barrel for spooling the second cable portion, and two side plates, wherein one side plate separates the reel from the first part of the drum, and an external annular wall is provided between the side plates of the reel, the diameter of the external annular wall being greater than that of the barrel of the reel;
  wherein one end of the first cable portion is designed to be connected to the audio equipment being suspended, and the second end of the first cable portion is fastened to the first part of the drum and connected to the second cable portion;
  one end of the second cable portion is connected to the first cable portion and is inserted into the reel, being fastened in the region of its annular wall, and the second end of the second cable portion is led out out of the reel, being fastened in the region of the barrel of the reel, and is designed to be connected to an external signal path; and

- a drive connected to the drum and configured to actuate the drum;
  wherein

  inner surface of the reel side plates is coated with a sliding material;
  the cable inside the reel has a coating that provides sliding of the cable relative to adjacent coils and relative to the sliding material covering the reel side plates.

[0017] In one embodiment, the audio equipment is one of a microphone and a loudspeaker.

[0018] In one embodiment, the side plates, the barrel and the annular wall of the reel serve as walls of said compartment.

[0019] In one embodiment, at least one of the side plates, the barrel or the annular wall of the reel is separated from respective wall of the compartment.

[0020] In one embodiment, the annular wall and/or the barrel of the reel presents a series of connecting elements that connect the reel side plates and are arranged along the line of the circumference with center at the axis of the reel, the distance between the connecting elements being chosen to prevent the cable from bulging out from the reel.

[0021] In one embodiment, the annular wall and/or the reel barrel presents a solid wall arranged along the line of circumference with center at the axis of the reel.

[0022] In one embodiment, the distance between the annular wall and the reel barrel is not less than the triple number of coils of the reel in the fully wound state.

[0023] In one embodiment, the sliding material presents sliding pads laid on the inner surface of the reel side plates, the total gap between the cable and the pads being less than one diameter of the second cable portion.

[0024] In one embodiment, the pads present films of Lavsan or polyethylene terephthalate.

[0025] In one embodiment, the sliding material is a coating applied to the inner surface of the reel side plates, the total gap between the cable and said coating being less than one diameter of the second cable portion.

[0026] In one embodiment, the sliding material is grease, the total gap between the cable and the reel side plates being less than one diameter of the second cable portion.

[0027] In one embodiment, the cable coating within the reel is grease.

[0028] In one embodiment, the cable coating within the reel is a semi-synthetic grease containing anti-scuff additives and a solid filler.

[0029] In one embodiment, sheath of the second cable portion is sliding.

[0030] In one embodiment, the second cable portion and the first cable portion are made of different types of cable.

[0031] In one embodiment, the second cable portion and the first cable portion are made of the same type of cable as a whole.

[0032] In one embodiment, the second cable portion presents a balanced cable with quadruple conductors in 2*2 structure.

[0033] In one embodiment, the second cable portion comprises a cable filled with filaments or fibers.

[0034] In one embodiment, the second cable portion presents a cable with a tinned copper braided shield covering at least 95% of the cable surface.

[0035] In one embodiment, the second cable portion presents a cable having cross-linked polyethylene insu-

lation.

[0036] In one embodiment, the second cable portion comprises a cable with stranded conductors made of annealed copper with a wire diameter of less than 0.1 mm.

[0037] The advantages offered by the present invention include increased versatility, reliability and service life of the winch.

Brief Description of the Drawings

[0038] The invention is further illustrated by the description of preferred embodiments of the invention with reference to the accompanying drawings, in which:

Fig.1 shows a prior art winch.
Fig.2 is a general view of a winch in accordance with the present invention.
Fig.3 is a side view of a winch drum in accordance with the present invention.
Fig.4 is another view of the winch drum.
Fig.5 is a schematic view of a reel with laid coils of the second portion of the cable.
Fig.6 is a schematic view of the process of winding the reel from one extreme position to another extreme position.
Fig.7 is a schematic view of a part of the drum with laid coils of the cable and the wire rope.
Fig.8 shows schematically reaction forces of the support, arising at the points of contact of the cable and the wire rope with elements of drawing path.
Fig.9 is a schematic view of audio equipment suspended on the carrier wire rope with the cable connected to it.

[0039] It should be understood that the figures may be presented schematically and not to scale, and they are intended primarily to enhance understanding of the present invention.

Detailed Description

[0040] Embodiments of the invention are not limited to the embodiments described herein, and a person skilled in the art will be able to propose, based on the information set forth in the description and the knowledge of the prior art, other embodiments of the invention without departing from the spirit and scope of the present invention.

[0041] Elements mentioned in the singular do not exclude the plurality of elements, unless otherwise specified.

[0042] A winch in accordance with the present invention is intended for remotely controlled raising and lowering of audio equipment. The audio equipment can be, for example, microphones for audio recording during concerts, loudspeakers for creating the necessary acoustic stage during performances, and any other suitable equipment. The winch is mounted over the point at which the audio equipment is to be positioned, and can be mounted either on a fixed base, such as ceiling structures, technical decks or grates, or a movable base, for example, soffits.

[0043] In accordance with the exemplary embodiment of the present invention depicted in Fig.2, the winch comprises a housing 1 consisting of a metal frame 2 with metal (for example, aluminum) panels 3 fixed on it. At least some of the panels are removable to allow for maintenance, start-up, adjustment, etc. Alternatively, both the frame and the housing panels can be made of other materials that provide required mechanical and strength characteristics, for example, plastics, metal-plastic composites, etc.

[0044] The housing encloses all of the basic mechanical units of the winch: a drum 4, a drive 5, and a stacker 6.

[0045] Audio equipment is suspended on a cable 7 or, if appropriate, on a carrier wire rope 8 (shown further in Fig.3). The drum 4 of the winch is intended for spooling and unspooling the cable 7. Hereinafter, it is meant that the carrier wire rope 8 can also be spooled on the drum. The drum 4 has a split construction and consists of two parts. In a first part 10 of the drum, a first portion 7 of the cable is spooled, and in a second part 11 of the drum, a second portion 9 of the cable is spooled, which makes the signal path continuous. A partition 13 (optional, see Fig.4) separates the first part 10 of the drum from the second part 11 of the drum.

[0046] During spooling the first cable portion 7 is laid on the drum coil to coil from one edge of the first part of the drum towards the other edge. One end of the first cable portion 7 is intended to be connected to the audio equipment being suspended; for this purpose, it can be provided with a connector and/or a fastening element, while the second end of the first cable portion 7 is fixed on the first part 10 of the drum and connected to the second cable portion 9.

[0047] The second part 11 of the drum is intended for spooling the second cable portion 9 and forms a compartment enclosing a reel 15 having two flat side plates (or, in other words, stoppers, sidewalls) 16 and 17 and a barrel located on a central bushing 14 of the drum (or in other words, a base) 18, on which the second cable portion 9 is spooled. The reel barrel can have either cylindrical shape or any other suitable shape, for example, a cylinder with a V-notch with rounded edges for cable outlet. The arrangement of the reel 15 on the central drum bushing 14 provides rotation of the reel simultaneously with the first part 10 of the drum.

[0048] One of the reel side plates (16) separates the reel from the first part 10 of the drum. The reel side plates 16 and 17 are joined together by an outer annular wall 19 having a diameter greater than the diameter of the reel barrel 18.

[0049] One end of the second cable portion 9 is connected to the first cable portion 7, fixed in the region of the reel annular wall 19 and inserted into the reel either through the annular wall 19, or next to it through one of the side plates (for example; Fig.3 shows schematically

that the second cable portion 9 is inserted into the reel through the side plate 16 near the annular wall 19).

[0050] Second end of the second cable portion 9 is fixed in the region of the reel barrel and led out from the reel, for example, through a hole in the reel barrel or in the side plate near the barrel, or through the aforementioned V-notch in the barrel for cable outlet. The led out end of the second cable portion 9 is intended to be connected to an external signal path, for which purpose it can comprise a connector and/or a fastening element on it.

[0051] Therefore, the second cable portion (or, more precisely, the segment of the second cable portion between its ends) is laid into the cavity between the side plates, the barrel and the annular wall of the reel, as shown in Fig.5.

[0052] Fig.6 shows the process of winding the second cable portion from one extreme position to the other extreme position. In Fig.6, the central bushing is stationary, and the compartment (reel) rotates. The fixed end of the second cable portion is led out through a central bushing having minimum radius limiters. The fixed end of the second cable portion is intended to be connected to an external signal path connected to the external audio equipment. The connection point of the second cable portion to the external signal path can be fixed to the winch housing. The movable end of the second cable portion is led out of the reel through the annular wall or the side plate into the first part of the drum, where the first cable portion is connected to it. When the drum rotates, the movable end of the second cable portion rotates with the drum around the central bushing, thereby pulling the rest of the second cable portion laid in the reel. With this, the tension and the range of bending angles of the cable in the region of the movable end are small and relatively constant, and twisting is practically absent. The remaining parts of the second cable portion experience uniform small bends and straightening with a slight tension. All parts of the reel move together at the same time, thereby reducing negative impact on the cable.

[0053] In the middle of the drum rotation cycle, the second cable portion changes the direction of winding. In addition, in the middle of the cycle, the tension and the range of bending angles of the cable in the region of the fixed end are small, and twisting is practically absent. In an exemplary embodiment, the second cable portion contains ten cable coils, this allowing the drum to make 20 revolutions between extreme positions in which the second cable section is tightened until it stops.

[0054] When rotation reverses, a loop is formed on the second cable portion, which should be able to slide and eventually come out completely. If the winch is unspooled or fully spooled, then no loop will form at the reversal. But if the reversal occurs not at the extreme points, a movable loop is formed almost always. If the reversal occurs several times at a sufficient distance (for example, more than one or two revolutions of the drum), then a loop is formed at each reversal. The number of loops can be 3-4, rarely more, because due to the cable rigidity adjacent loops are mutually compensated. The loads occurring on the cable during reversals are evenly distributed between the cable portions, and ends of the cable do not experience excessive tension, bending and twisting.

[0055] To ensure operability of the system, it is necessary to ensure good sliding of the cable not only on the side plates of the reel, but also between coils. Only in this case loops can unfold freely. For this purpose, inner surface of the reel side plates is covered with a sliding material, and the cable inside the reel has a coating that provides sliding of the cable both relative to adjacent coils and relative to the sliding material covering the reel side plates. The gap between the reel side plates and the cable (taking into account the extent of surface coated) should be small to prevent the cable from sinking into it.

[0056] Therefore, the structure according to the present invention is reliable and simple, and provides a continuous signal path from the suspended audio equipment to the point of connection to an external signal path connected to the external audio equipment, thereby increasing the noise immunity of the signal path. At the same time, cable in the structure is subject to lower loads, which further increases its wear resistance and noise immunity, and also enables using the winch structure to work in any winding ranges and employing the same winch in different stage configurations. Therefore, increased versatility, reliability and lifespan of the winch are provided.

[0057] In one embodiment, the side plates, barrel and annular wall of the reel serve as walls for the compartment for the second part 11 of the drum, that is, the reel is essentially a compartment. In this case, in particular, the side plate 16 can serve as the partition 13. Thereby a compact design is ensured.

[0058] In other embodiments, the compartment for the second part 11 of the drum may have additional walls around the reel 15, both fixed on the drum and fixed on the housing, and then at least one of the side plates, barrel or annular wall of the reel is separated from the corresponding wall of the said compartment. This can allow for additional protection measures for the second drum part, such as additional shielding, preventing damage to the cable and fall out of the content of the second drum part into the cavity of the housing 1.

[0059] Each loop formed at the drum rotation reversal has a size of about 3-4 cable diameters and increases the radius of reel winding. In unfavorable circumstances, space for the reel may not be enough, and mechanical stress on the cable increases. In these conditions, it is important to ensure that there are no "pockets" in the reel, into which the coils can be squeezed out. Cylindrical reel is the best for this. For this purpose, its annular wall and barrel should be positioned along the circumferential line (or near it) with the center at the reel axis.

[0060] Structurally, this can be achieved, for example, by making the annular wall and/or the barrel of the reel

in the form of a series of connecting elements joining the side plates of the reel and arranged along the circumferential line with the center at the reel axis, and the distance between the connecting elements should be chosen so as to exclude bulging of the cable from the reel (for example, it should be less than 2-3 cable diameters). Such connecting elements can be, for example, metal studs 12, which provide a threaded connection, as shown in Fig.4 and 5, bolts, and elements of any other shape, size, material and method, connections suitable for a particular application. This option can provide structural rigidity, reduce weight and material consumption, and increase accuracy of setting the distance between the reel side plates for providing a uniform specified load on the cable in all parts of the reel, and thereby enhancing the reliability.

[0061] Another design option is to make the annular wall and/or the barrel of the reel as a solid wall arranged along the circumferential line with center at the axis of the reel. The solid wall can be either independent and made of a hard material, or, for example, it can be a flexible ring made of metal tape, laid along the connecting elements that define the size of the compartment (for example, abutting against them). This option can further reduce the likelihood of the reel content falling out or bulging outward, and thereby enhance the reliability.

[0062] To provide sufficient space in the reel for loops formed during the reel rotation reversal, which would reduce the likelihood of increasing the load on the cable, and to reduce the range of bending angles of the moving cable portion, it is preferable to choose the distance between the annular wall and the reel barrel at least three times the number of coils of the reel in a fully spooled state. Thereby, the reliability can be enhanced.

[0063] As a sliding material covering side plates of the reel, polymer pads made of a highly sliding material (for example, Lavsan or polyethylene terephthalate i.e. Teflon) can be used. The total gap between the cable and the pads should be less than one diameter of the second cable portion.

[0064] The sliding material covering the reel side plates may be another hard or soft coating applied to the inner surface of the reel side plates, for example, by spraying, gluing, electroplating, etc., and having suitable sliding properties with respect to the cable coating. The total gap between the cable and the coating is less than one diameter of the second cable portion.

[0065] The sliding material covering the reel side plates can be grease, in which case the total gap between the cable and the reel side plates should be less than one diameter of the second cable portion.

[0066] The cable inside the reel may be coated with grease.

[0067] For example, if Teflon pads are applied to the side plates of the reel, and the second cable portion has a PVC sheath, friction will appear in the PVC-PVC and PVC-Teflon pairs in the reel cavity, and then, as numerous experiments conducted by the authors have shown, the best sliding indicators of the cable can be achieved by coating it with a grease such as drill grease. The grease should have good adhesion to plastics and low droplet formation within the operating temperature range, have a consistency of 2-3 according to the NGLI classification and be passive with respect to PVC. These conditions are met by e.g. EP KPF2/3-K30 semi-synthetic greases according to DIN 51825, containing extreme pressure additives (P) (i.e. additives to reduce friction and wear in the increased friction zone and/or to increase the permissible load) and a solid filler (F) including, for example, molybdenum disulfide. This combination best protects the PVC cable from stress and provides the winch with the above advantages. Here, EP indicates the ability to work at extreme pressure and is not obligatory, but the additives that give this property to grease have a beneficial effect at low pressures as well, so this option provides the cable with additional reliability.

[0068] If the reel (or, in particular, the reel side plate) is made of PVC (or covered with a PVC material), and the second cable portion has a PVC sheath, then only friction in PVC-PVC pairs will occur in the reel cavity, and then it is enough to cover the cable and side plates with a grease that improves sliding in this pair. This facilitates assembly of the reel while retaining all of the previously mentioned advantages.

[0069] Alternatively, a cable having no PVC sheath, but having a different, sliding sheath, or covered with a sliding sheath, can be selected. In such a case, grease may not be necessary if the cable sheath provides acceptable sliding properties in cable-cable and wire-reel pairs. It also facilitates assembly of the reel while retaining all of the aforementioned advantages.

[0070] External signal path, to which the fixed end of the second cable portion is connected, and external audio equipment, may be of different nature. For example, if the audio equipment suspended on the winch is a microphone, then the external signal path is the output signal path with respect to the winch and can be connected, for example, to audio recording equipment. In an alternative embodiment, if the suspended audio equipment is a loudspeaker, then the external signal path is the input signal path for the winch and can be connected to, for example, a record player, mixing board, etc.

[0071] Depending on particular application requirements, the cable can be made as a composite cable, i.e. the second cable portion and the first cable portion are made of different types of cable, and one-piece, i.e. the second cable portion and the first cable portion are made of the same type of cable as a whole. The composite option does not affect the quality of the signal passing through the cable, since the junction between the first and second cable portions is rigid, immovable and reliable. This increases versatility of the winch while maintaining all other advantages.

[0072] It should be noted that the best reliability and durability factors for use in the reel are demonstrated by a cable observing the following requirements:

- Mechanical strength of conductors and insulation together with good flexibility;
- Resistance to extension and compression strain;
- Low intrinsic microphone effect;
- High shielding properties.

[0073] On this basis, in embodiments of the present invention, the following types of cables can be used as the second cable portion.

1. Special symmetric (balanced) cable for connecting microphones. Frequency response of the cable of such has a roll-off beyond the 20 kHz frequency range.
2. Cable having shield with at least 95% surface coverage. Tin plated copper braid shield is suitable for this. Foil shields wear out faster, while spiral (twisted) shields have a poorer surface coverage (commonly about 70%) and larger gaps between conductors.
3. Cable with 2*2 structure (quad cable), referred to as "pupinized (coil-loaded) quadruple". Quad conductors are used to reduce the characteristic impedance of the cable, and have a significant advantage over conventional microphone pairs. An additional advantage of the quadruples is the perfectly round shape of the cable, which prevents situations where the twisted cable becomes flat, the gap between the cable and the walls increases, and the loop falls into it and is clamped.
4. Cable with filament or fiber fillers. In the reel, the cable is periodically subjected to strong compression and stretching. Upon strong stretching, loops, "bulges", etc. may appear inside the cable. Strength, tensile strength and shape stability of the cable can be ensured by using fillers made of textile (cotton) threads and Lavsan fibers. The cable with such filling will not be flattened or stretched.
5. Cable with cross-linked PE Insulation has low intrinsic microphone effect. This material ensures additional benefits: high flexibility, reduced linear capacitance, high resistance to electrical voltage.
6. Cable with stranded annealed copper conductors has the necessary flexibility owing to the large number (30-40) of very thin conductors of less than 0.1 mm in diameter.

[0074] It should be understood that the above embodiments can be combined to further improve performance of the cable and enhance reliability and durability of the winch.

[0075] To form even coils of the first cable portion 7 (and, if necessary, the carrier wire rope 8) on the first part of the reel in the winch, a stacker 6 can be used. When the drum is rotated by the drive, the force from the drive is also transmitted to the stacker with a carriage, which moves linearly along the axis of the drum 4 such that during one revolution of the drum it moves at one step of winding the first cable portion. With this, the cable passes through the hole in the carriage and is spooled on the drum in one row, coil to coil. The stacker comprises adjustable sensors of extreme positions of the carriage.

[0076] The stacker in accordance with the present invention has the least possible effect on the stacking and unwinding process. Guide fluoroplastic sleeve of the stacker, through which the first cable portion passes, is located as close as possible to the point where the cable leaves the reel on the vertical tangent to the generatrix. The cable changes its angle when touching the sleeve only in the extreme positions of the drum.

[0077] To determine the angle of rotation of the drum, any suitable known rotation angle sensors mounted on the axis of the drum or in a suitable place on the winch housing can be used, for example, optical, mechanical, magnetic and other rotation angle sensors. According to an exemplary embodiment, a mirrored engraved disc is mounted on the reel shaft as part of an optical encoder. Marks on the disc allow reading the position of the drum. Emitter and photodetector of the encoder are mounted on the frame. Encoder signal is used to operate a servo drive, which implements smooth acceleration, deceleration, stabilization of the movement speed, approaches to a point at a given coordinate without participation of an operator in a fully automatic mode, and synchronization of winches in a set.

[0078] According to an exemplary embodiment, a drive consisting of a DC motor with an integrated self-locking worm gear is used to drive the winch drum. This solution provides the necessary condition that the drum must be fixed all the time when it is not rotating, including when it is de-energized. However, the drive has a friction clutch to mate with the motor. The friction clutch is designed to protect the gearbox, cable and wire from external mechanical effects. A typical situation occurring when winches are installed is that the space behind the ceiling is densely packed with lighting and stage equipment, and trusses, decorations, and lighting devices are suspended from the ceiling. Suspension of audio equipment, that is, the cable connector and the load, and the wire rope, when moving up and down, very often touch or even catch suspended structures. Friction gear eliminates the risk of breakage or entanglement under these conditions and also makes maintenance very easy. Since the encoder is rigidly connected to the drum, rather than to the motor, slippage does not affect the coordinate reading. Adjusting nut can change the force on the friction clutch spring washer and thus change the shear force. Force is transmitted to the drum and stacker by a chain drive. To tension the chain, an additional bypass sprocket with an adjusting groove is used. It should be noted that in an alternative embodiment, any other suitable motor, such as a synchronous motor, an induction motor, etc., can be used as the actuator. Moreover, to transmit the force from the actuator to the drum, a belt drive, a gear drive, a friction drive, etc. can be used as an alternative.

[0079] To control elements of the winch, a controller can be mounted in the housing. The sensor of the drum

angular position and the stacker end sensors are connected to the controller. The controller comprises non-volatile memory of system settings. The controller independently calculates the movement ballistics. Thereby smoothness and absence of jerking or swaying movements are provided.

[0080] In an alternative embodiment, the elements of the winch can be controlled by an external controller mounted in a remote control unit.

[0081] It should be noted that the lifting capacity of the winch for audio equipment is limited by mechanical characteristics of the signal (acoustic) cable, on which the audio equipment is suspended. To raise and lower heavy audio equipment, for example, large loudspeakers, a number of measures are required to ensure the necessary safety of the work performed and the reliability of the equipment. To provide the increased lifting capacity in the winch, in one embodiment the audio equipment is suspended using a carrier wire rope.

[0082] In this embodiment, the winch drum 4 is designed to spool and unspool the cable 7 and the carrier wire rope 8 (shown further in Figs. 7 to 9). The drum 4 has a split structure and consists of two parts. The first cable portion and the carrier wire rope, designed to suspend the audio equipment, are spooled on the first part of the drum, and the second cable portion, which makes the signal path continuous, is spooled on the second part of the drum.

[0083] In this embodiment, the first cable portion 7, together with the wire rope 8, is laid during winding on the drum coil to coil from one edge of the first part of the drum towards the other. Since radius of the carrier wire rope coil remains constant, simple one-to-one dependence of coordinates of the audio equipment suspension and the angle of rotation of the drum is achieved, thus high accuracy of positioning of the audio equipment can be provided.

[0084] It should be noted that in this embodiment the stacker 6 is also used to form smooth coils of the cable 7 and the carrier wire rope 8 on the drum. When the drum is rotated by the drive, the drive force is also transmitted to the stacker with a carriage, which moves linearly in the direction along the axis of the drum 4 such that during one revolution of the drum one step of winding the cable with the carrier wire rope is performed. With this, the cable and the carrier wire rope pass together through the hole in the carriage and are wound on the drum in one row, coil to coil.

[0085] The carrier wire rope and the cable are wound on the same drum together and simultaneously. The wire rope of required strength usually has a noticeably smaller thickness compared to the cable, i.e. the wire rope and the cable have different diameters and, accordingly, different coil lengths on the drum. This has two consequences:

1. Wire rope is placed on the drum in the gaps formed by adjacent coils of the cable, practically taking no space (see Fig.7) . Moreover, the cable can be laid on the drum tightly, almost as without the wire rope. This is important for maintaining the drum capacity. It is worth noting that a conventional steel wire rope twists under load. Since during raising and lowering the linear load (i.e. reduced to a unit length) changes, the twisting force also changes. Therefore, the load can rotate on the wire rope, and the wire rope twists together with the cable.
2. Additional measures are required to align the lengths of the carrier wire rope and cable. Length of coil of the cable or the wire rope laid on the drum depends on its thickness (see Fig.7) .

[0086] Fig.7 shows schematically a part of the drum with laid cable and wire rope coils, where ***rd*** is the radius of the drum, ***r1*** is the radius of coil of the cable having diameter ***d1***, ***r2*** is the radius of coil of the wire rope having diameter d2, where $r1 = rd + \frac{d1}{2}$ and $r2 = rd + \frac{d2}{2}$.

[0087] The difference in coils lengths $\Delta L = 2\pi*(r1-r2) = \pi*(d1-d2)$ does not depend on the drum diameter, but depends only on the difference in diameters of the cable and the wire rope.

[0088] For example, with the cable 6mm thick and the wire rope 2mm thick, respectively, about 12mm difference approaches on each coil.

[0089] When laying, it is very desirable to straighten the cable twisted with the wire rope. Then the laying step will be stable, and the winding itself will be neat. This is necessary, among other things, for smooth feeding, with no jerking. The straightening occurs due to the forces arising at the points of contact of the cable with elements of the drawing path, i.e. the stacker and the winch exit hole (see Fig.8). Arrows in Fig.8 shows direction of the support reaction forces. The cable-wire rope-support system has a stable energy state, referred to as "potential energy well", at the point with minimum deviation from the shortest path of the cable and wire rope. With increasing the deviation, the arc length increases, which is equivalent to increasing the movement speed, i.e. the kinetic energy of the system, and this requires additional work. The system can "escape" from the "potential energy well". That is, the twist (the cable and wire rope twisted state) can "slip" through the stacker. This happens if the force holding the pair (cable and wire rope) in the twisted state is, for some reason, greater than the component of the support reaction force directed to untwisting.

[0090] When the twisted cable and wire rope pair straightens, the load suspended at the end rotates. If the moment of inertia of the load does not allow its rotation in accordance with the speed of unwinding the pair, the twist pitch decreases. This changes the balance of kinetic and potential energy of the system and will inevitably lead to its escape from the "potential energy well".

[0091] Practical application of these considerations is such that in most cases it is sufficient to choose the speed of raising to ensure the necessary laying of the cable and wire rope.

[0092] For even and accurate laying, the cable close to the drum should always be tensioned, especially when the system is lowered. The tension force must exceed the friction force of the cable against the stacker carriage, so that when the cable is unspooled from the drum, no loops are formed between the drum and the stacker. Own weight of the cable is not enough for this. In addition, when the winch is unwound, length of the wire rope and the cable changes differently. Therefore, the following measures have been taken to tension the cable and compensate for the run-on.

[0093] The cable has a larger diameter than the wire rope. The winding radius of the cable is larger, so the cable length must be longer. The carrier wire rope is tensioned by the suspended load, and it is proposed to use a resilient member, for example, a spiral spring 19 (see Fig.9), to tension and heave the changing excess length of the cable. In an alternative embodiment, a resilient band, for example, can be used as the resilient member. The spring is fixed at one end to the audio equipment suspension point, the same where the wire rope is fixed, while the other end of the spring is attached to a clamp that can be moved along the cable. In general, the clamp is fixed in the lower section of the first cable portion. In an alternative embodiment, one end of the spring is not fixed at the suspension point, but close to it, for example, on the wire rope or on the audio equipment itself near the suspension point. The cable portion between the clamp and the audio equipment is not subject to tension and forms a loop. The spring provides a slight tension on the cable above the clamp and heaves the loop that changes its size depending on the suspension height. The spring can be connected to the cable with a collet clamp (for example, using a standard cable connector having a plastic collet).

[0094] Referring to Fig.9, the static equilibrium equation in scalar form looks as:

$$P = Fr + kX,$$

where P is the force of gravity acting on the suspended load, Fr is the wire rope tension force, kX is the cable tension force, equal in modulus to the spring traction force.

[0095] Magnitude of the cable tension force can range from zero, when the spring is in free state, to a value of P, modulo the force of gravity, if the entire load hangs only on the spring and, therefore, on the cable. In practice, selection of the tension force is done in a fully unwound state, with a load suspended from the wire rope and a detached spring. Position of the collet on the cable is chosen such that the cable tension is minimal sufficient for normal operation of the winch stacker. At raising, the tension will increase and reach maximum at the highest point. This is because the length of the cable coil on the drum is greater than that of the wire rope coil. The cable rises faster. If at the beginning the tension force was F1, at the end it will be $F = F1+k*(\Delta L*N)$, brackets showing the run-on of the length difference on N coils (in an exemplary embodiment, the run-on is 15-20 cm) . The task of choosing the constant (and size) of the spring k is that at the end of raising, the tensile force does not exceed a predetermined value dependent on e.g. the cable strength or even the load weight.

[0096] One more feature of practical implementation is that when the working load is detached and the winch is wound, the weight of the remaining "tail" may not be enough for safe unwinding, so a small load can be mounted at the cable lower portion.

[0097] According to another embodiment, there is provided a winch for audio equipment, comprising a housing that contains a drum for spooling the cable, and a carrier wire rope for suspending audio equipment, one end of the cable being intended to be connected to said audio equipment, and the other end of the cable being intended to be connected to fixed point of connection to an external signal path. The stacker, similar to the exemplary embodiment described above, is configured to lay the cable and the wire rope on the drum coil to coil. The drive is connected to the drum and the stacker to actuate them. Moreover, to ensure tension of the cable near the drum, a resilient member is provided, one end of which is fixed at the point of suspension of the audio equipment or near it, and the other end of the resilient member is connected to a clamp mounted in the lower section of the cable, the cable portion between the clamp and the audio equipment experiences no tension.

[0098] The winch has a simple and reliable structure, noise immunity of the signal path, and also enables increasing the service life and accuracy of positioning the audio equipment.

[0099] The winch in accordance with the present invention ensures positioning of audio equipment with an accuracy of 1 mm.

[0100] The winch in accordance with the present invention can be used as part of a positioning system for audio equipment, consisting of several such winches and a control unit. The control unit is configured to control the winches for positioning several pieces of audio equipment in certain positions above the stage in accordance with a predetermined layout. Furthermore, the control unit is configured to save multiple layouts of audio equipment above the stage so that to reproduce them in future. In accordance with one embodiment, the control unit comprises information display means (e.g. display) to display information representing possible layouts of audio equipment or other information necessary to control the system. Also, the control unit in accordance with one embodiment comprises input means, such as a keyboard, mouse, touch panel, touchpad, joystick, etc., for receiving control actions from a user to control the sys-

tem. In an alternative embodiment, the control unit can be connected to a mobile terminal that performs functions of displaying information to the user and receiving control actions from the user. The control unit can communicate with the mobile terminal and with the winches using both wired and wireless links. The system ensures high-precision positioning of audio equipment in accordance with a given layout in a simple and reliable manner.

[0101] It should be understood that although terms such as "first", "second", "third" and the like may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used only to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer, or section may be referred to as second element, component, region, layer, or section without departing from the scope of the present invention. As used herein, the term "and/or" includes any and all combinations of one or more of respective listed items. Elements mentioned in the singular do not exclude the plurality of elements, unless otherwise specified.

[0102] Functionality of the element specified in the description or claims as a single element can be implemented in practice by means of several components of the device, and vice versa, functionality of the elements specified in the description or claims as several separate elements can be implemented in practice by means of a single component.

[0103] In one embodiment, elements/units of the present device are enclosed in a common housing; they can be arranged on the same frame/structure/printed circuit board and connected to each other structurally by assembly operations and functionally by communication lines. The communication lines or channels of, unless otherwise indicated, are standard communication lines known in the art, the material implementation of which does not require creative effort. Communication line can be a wire, a set of wires, a bus, a track, a wireless communication line (inductive, radio frequency, infrared, ultrasonic, etc.). Communication protocols over the communication lines are known to those skilled in the art and are not specifically disclosed.

[0104] Functional relationship of elements should be understood as a relationship that ensures correct interaction of these elements with each other and implementation of particular functionality of the elements. Specific examples of functional relationship can be a relationship enabling exchange of information, a relationship enabling transmission of electric current, a relationship enabling transmission of mechanical motion, relationship enabling transmission of light, sound, electromagnetic or mechanical vibrations, etc. The specific type of functional relationship is determined by the nature of the interaction of these elements, and, unless otherwise indicated, is provided by conventional means using conventional principles.

[0105] Structural design of elements of present device is known to those skilled in the art, and is not described separately in this document, unless otherwise indicated. Elements of the device can be made of any suitable material. The components can be manufactured using conventional methods, including, by way of example only, machining, investment casting, crystal growth. Assembly, joining, and other operations in accordance with the above description also correspond to the knowledge of a person skilled in the art and, therefore, are not explained in more detail here.

[0106] While exemplary embodiments have been described in detail and shown in the accompanying drawings, it should be understood that such embodiments are illustrative only and are not intended to limit the present invention, and that the invention should not be limited to the specific arrangements and structures shown and described, since various other modifications and embodiments of the invention without departing from the spirit and scope of this invention may be apparent to a person skilled in the art based on the information set forth in the description and knowledge of the prior art.

Claims

1. A winch for audio equipment, comprising a cable and a housing that contains:

- a drum designed for spooling the cable and comprising two parts disposed on a central bushing, wherein

  a first part of the drum is designed for spooling a first portion of the cable,
  a second part of the drum is designed for spooling a second portion of the cable and presents a compartment enclosing a reel that has, disposed on the central bushing, a barrel for spooling the second cable portion, and two side plates, wherein one side plate separates the reel from the first part of the drum, and an external annular wall is provided between the side plates of the reel, the diameter of the external annular wall being greater than that of the barrel of the reel;
  wherein one end of the first cable portion is designed to be connected to the audio equipment being suspended, and the second end of the first cable portion is fastened to the first part of the drum and connected to the second cable portion;
  one end of the second cable portion is connected to the first cable portion and is inserted into the reel, being fastened in the region of its annular wall, and the second end of the second cable portion is led out

of the reel, being fastened in the region of the barrel of the reel, and is designed to be connected to an external signal path; and

- a drive connected to the drum and configured to actuate the drum;
wherein

inner surface of the reel side plates is coated with a sliding material;
the cable inside the reel has a coating that provides sliding of the cable relative to adjacent coils and relative to the sliding material covering the reel side plates.

2. The winch according to claim 1, wherein the audio equipment is one of a microphone and a loudspeaker.

3. The winch according to claim 1, wherein the side plates, the barrel and the annular wall of the reel serve as walls of said compartment.

4. The winch according to claim 1, wherein at least one of the side plates, the barrel or the annular wall of the reel is separated from respective wall of the compartment.

5. The winch according to claim 1, wherein the annular wall and/or the barrel of the reel presents a series of connecting elements that connect the reel side plates and are arranged along the line of the circumference with center at the axis of the reel, the distance between the connecting elements being chosen to prevent the cable from bulging out from the reel.

6. The winch according to claim 1, wherein the annular wall and/or the reel barrel presents a solid wall arranged along the line of circumference with center at the axis of the reel.

7. The winch according to claim 1, wherein the distance between the annular wall and the reel barrel is not less than the triple number of coils of the reel in the fully wound state.

8. The winch according to claim 1, wherein the sliding material presents sliding pads laid on the inner surface of the reel side plates, the total gap between the cable and the pads being less than one diameter of the second cable portion.

9. The winch according to claim 8, wherein the pads present films of Lavsan or polyethylene terephthalate.

10. The winch according to claim 1, wherein the sliding material is a coating applied to the inner surface of the reel side plates, the total gap between the cable and said coating being less than one diameter of the second cable portion.

11. The winch according to claim 1, wherein the sliding material is grease, the total gap between the cable and the reel side plates being less than one diameter of the second cable portion.

12. The winch according to claim 1, wherein the cable coating within the reel is grease.

13. The winch according to claim 9, wherein the cable coating within the reel is a semi-synthetic grease containing anti-scuff additives and a solid filler.

14. The winch according to claim 1, wherein sheath of the second cable portion is sliding.

15. The winch according to claim 1, wherein the second cable portion and the first cable portion are made of different types of cable.

16. The winch according to claim 1, wherein the second cable portion and the first cable portion are made of the same type of cable as a whole.

17. The winch according to claim 1, wherein the second cable portion presents a balanced cable with quadruple conductors in 2*2 structure.

18. The winch according to claim 1, wherein the second cable portion comprises a cable filled with filaments or fibers.

19. The winch according to claim 1, wherein the second cable portion presents a cable with a tinned copper braided shield covering at least 95% of the cable surface.

20. The winch according to claim 1, wherein the second cable portion presents a cable having cross-linked polyethylene insulation.

21. The winch according to claim 1, wherein the second cable portion comprises a cable with stranded conductors made of annealed copper with a wire diameter of less than 0.1 mm.

22. The winch according to claim 1, further comprising:

- a carrier wire rope for suspending the audio equipment, said carrier wire rope being spooled onto the first part of the drum;
- a stacker configured to lay the first cable portion and the carrier wire rope on the drum coil to coil;
wherein the drive is further connected to the

stacker and configured to actuate the stacker;
wherein a resilient member is provided to provide tension of the first cable portion near the drum, one end of the resilient member being secured at or near the suspension point of the audio equipment, and the second end of the resilient member is connected to a clamp mounted in the lower section of the first cable portion, and the cable portion between said clamp and the audio equipment experiences no tension.

23. The winch according to claim 22, wherein the resilient member is a helical spring.

24. The winch according to claim 22, wherein the cable further comprises a load.

25. The winch according to claim 22, further comprising a controller for controlling the winch.

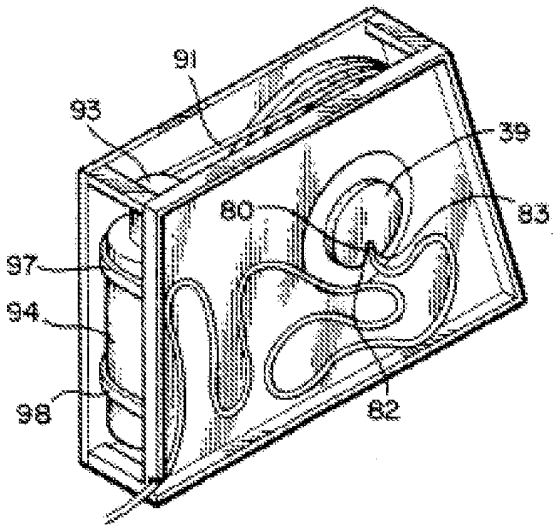
26. The winch according to claim 25, wherein the controller is configured to control the drive to set the audio equipment raising rate that provides necessary laying of the cable and the carrier wire rope.

27. An audio equipment positioning system comprising at least one winch according to claim 1 to 26 and a control unit.

28. The system according to claim 27, wherein the control unit comprises a display.

29. The system according to claim 27, wherein the control unit comprises information input means.

30. The system according to claim 27, wherein the control unit is connected to a mobile terminal configured to receive control actions from the user.



PRIOR ART

FIG. 1

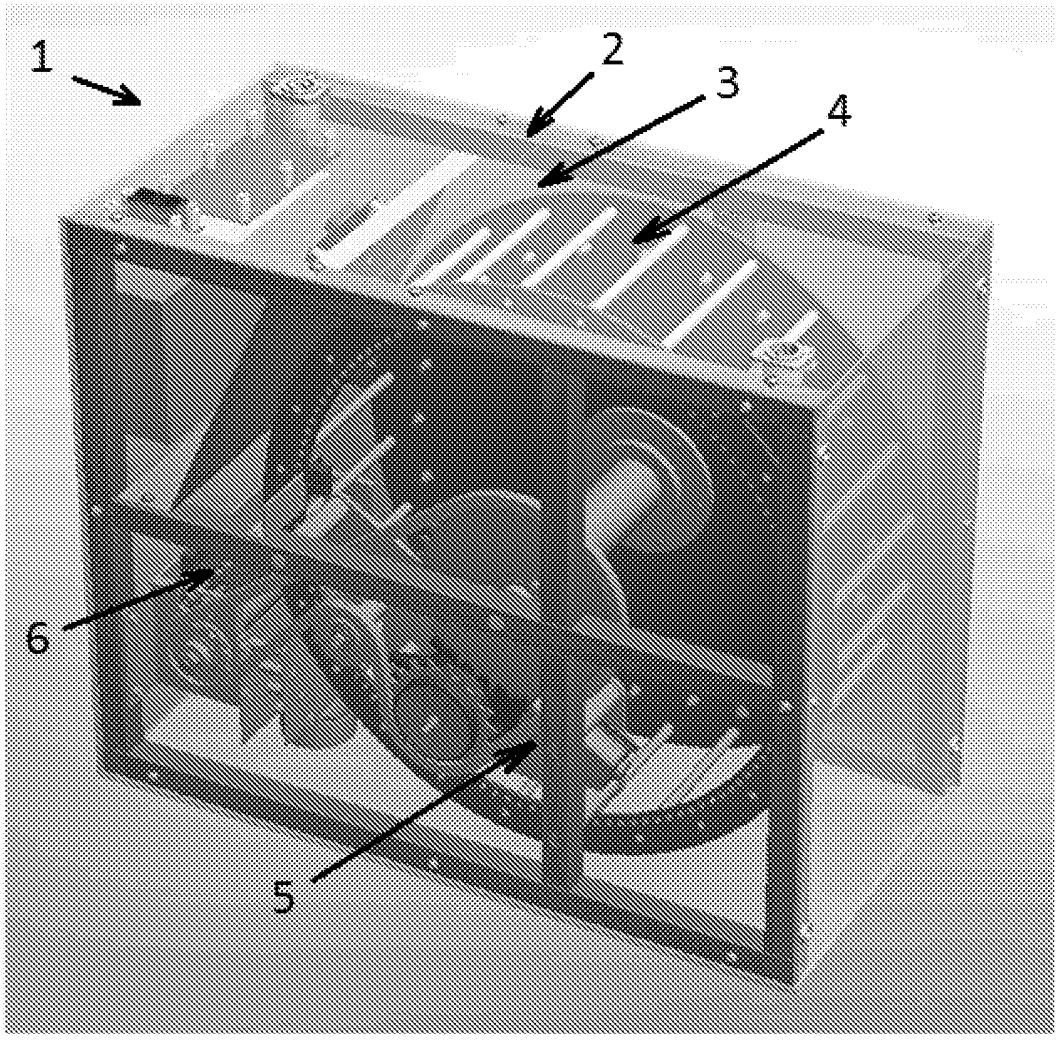


FIG. 2

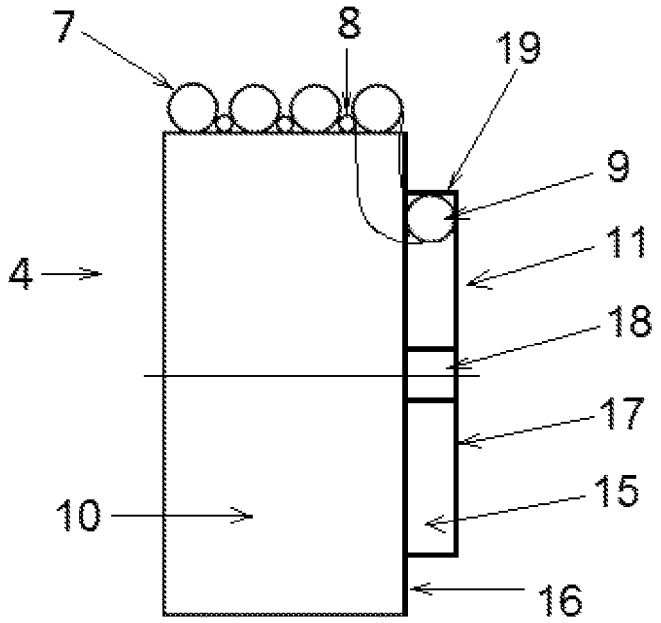


FIG. 3

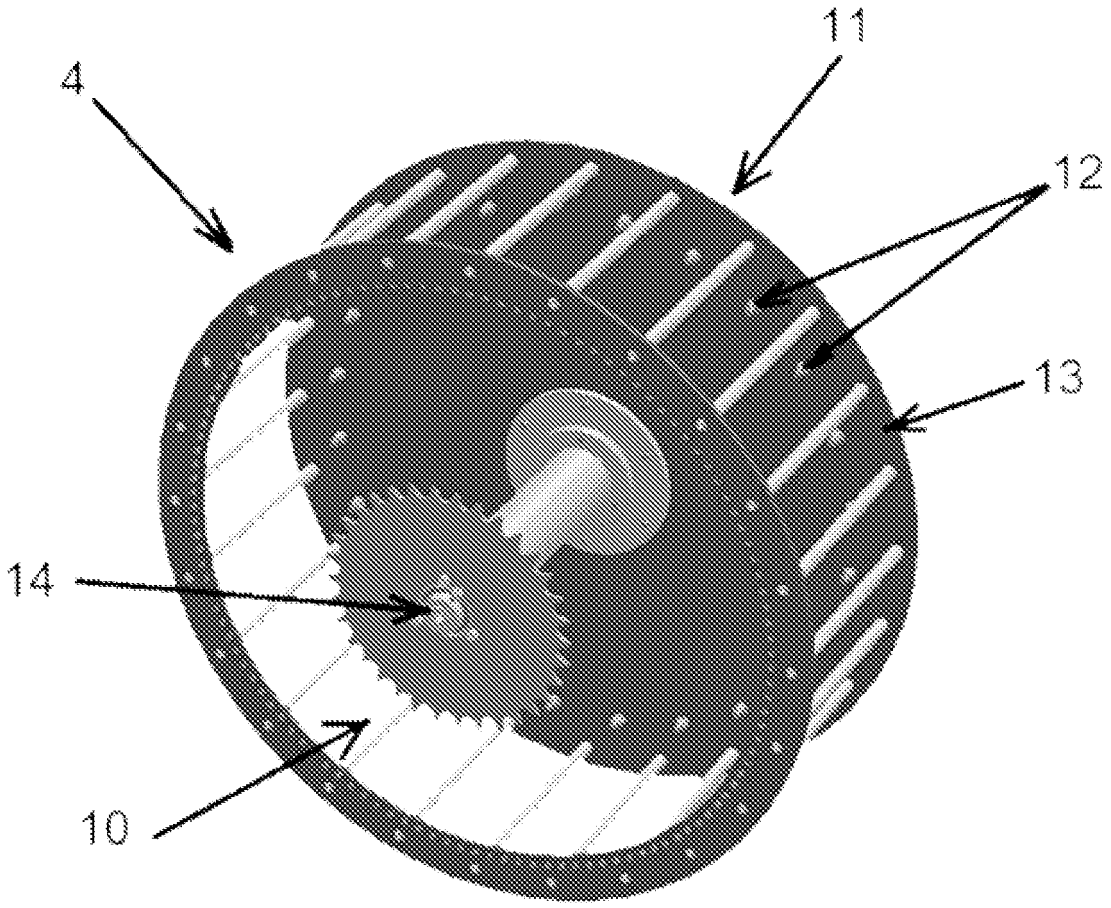


FIG. 4

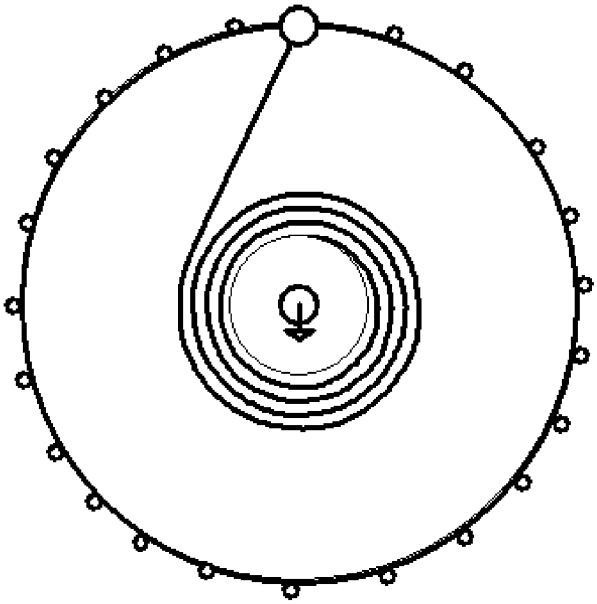


FIG. 5

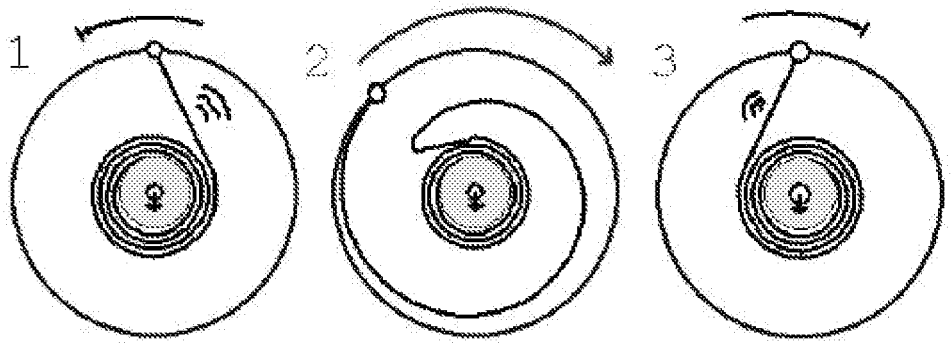


FIG. 6

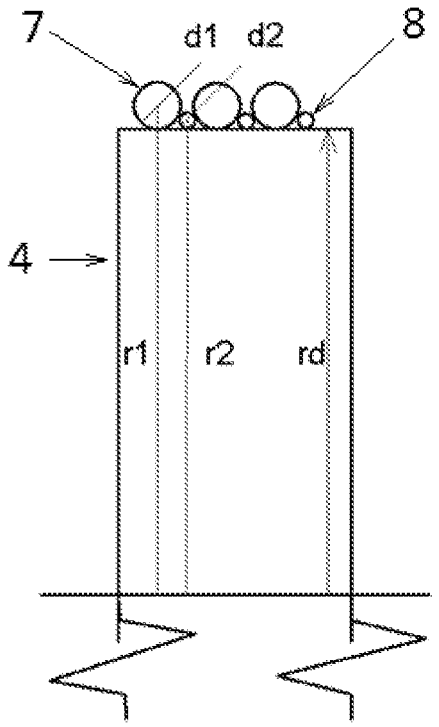


FIG. 7

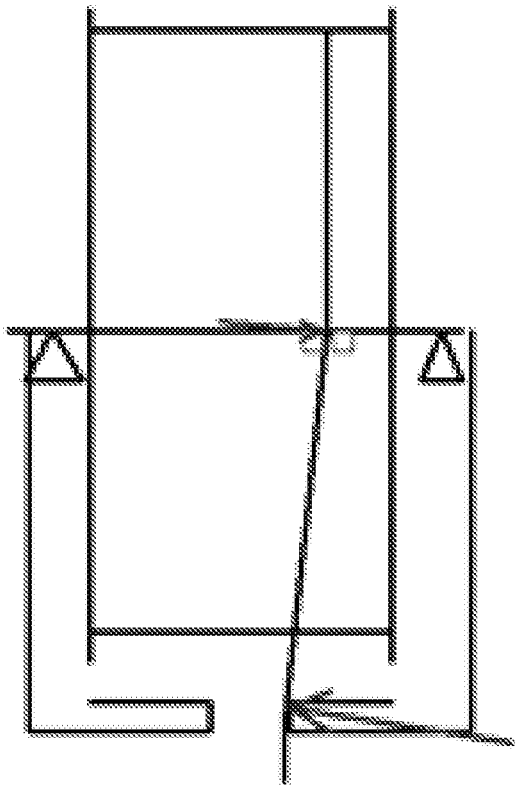


FIG. 8

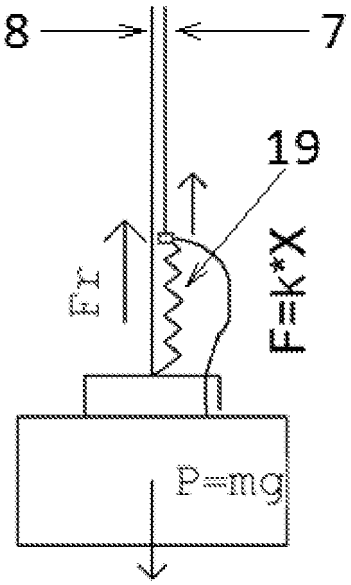


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 2020/050068

A. CLASSIFICATION OF SUBJECT MATTER

A63J 1/00 *(2006.01)* ***B65H 75/34*** *(2006.01)*
A63J 5/04 *(2006.01)* ***B66D 1/00*** *(2006.01)*

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A63J 1/00, 5/00, 5/04, B65H 75/00, 75/34, B66D 1/00, 1/14

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

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

PatSearch (RUPTO Internal), USPTO, PAJ, Espacenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5526997 A1 (XEDIT CORPORATION) 18.06.1996	1-30
A	RU 97275 U1 (KARMAEV EVGENY VLADIMIROVICH) 10.09.2010	1-30
A	CA 2414854 A1 (PRODUCTION RESOURCE GROUP EEC) 07.02.2002	1-30
A	FR 2258911 A1 (ARBED F DRAHTWERKE) 22.08.1975	1-30

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 August 2020 (28.08.2020)	03 September 2020 (03.09.2020)
Name and mailing address of the ISA/ RU	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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