Electronic apparatus having a vibration-sensitive constructional unit

The invention relates to an electronic apparatus having a vibration-sensitive constructional unit accommodated in a housing, the housing and the vibration-sensitive constructional unit being coupled by damping means.

Such an electronic unit is known, for example from DE 39 14 303 A1. This known apparatus uses helical springs with a linear spring-force characteristic in order to provide isolation from external vibrations and shocks between the apparatus chassis or deck and the mounting structure or housing of the apparatus. The vibration amplitude of such helical springs for excitation by vibrations of comparatively low frequency is larger than for excitation by vibrations of comparatively high frequency. In such apparatuses the vibration clearance for the vibration-sensitive constructional unit should therefore be adapted to the lowest excitation frequencies that occur in operation.

It is an object of the invention to provide an apparatus of the type defined in the opening paragraph, wherein the vibration clearance required for the vibration-sensitive constructional unit is reduced.

According to the invention this object is achieved in that the damping means comprise at least one spring arrangement having a spring characteristic which is progressive in three directions in space.

A progressive spring characteristic means that the spring force increases progressively, i.e. superproportionally, as the vibration amplitude increases. The spring characteristic, which is progressive in three directions in space, results in a progressive damping of vibrations in all three directions in space. The three directions in space are defined as directions in space of a Cartesian coordinate system. One axis of this Cartesian coordinate system is then preferably oriented in the direction of the longitudinal axis of the spring arrangement. Thus, vibrations that occur are damped progressively in three dimensions.

The vibration amplitude of the low-frequency vibrations is reduced as a result of the non-linear tuning of the springs with progressive spring characteristics. This results in a reduction of the vibration clearance required for the vibration-sensitive constructional unit in

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all three directions in space and, consequently, of the construction volume of the electronic apparatus in all three directions in space.

In the advantageous embodiment of the invention defined in Claim 2 the spring arrangement comprises a helical spring with non-linearly spaced turns. This non-linear spacing results in a non-linear spring characteristic of the helical spring which is progressive in the axial direction of the helical spring. A spring core is arranged inside the helical spring, the radial clearance between the turns of the helical spring and the spring core not being constant. Thus, it is achieved that as the vibration amplitude increases an increasing number of turns of the helical spring come into contact with the spring core, as a result of which the vibrations are damped progressively with increasing vibration amplitude and a spring characteristic is obtained which is progressive in space directions which extend radially with respect to the helical spring.

In the advantageous embodiment of the invention defined in Claim 3 the spring core is fixedly connected to the housing. The radial clearance between the turns of the helical spring and the spring core increases from the housing towards the vibration-sensitive constructional unit, i.e. near the housing the clearance between the turns of the helical spring and the spring core is comparatively small, while near the vibration-sensitive constructional unit it is comparatively large. Therefore, when the vibration-sensitive constructional unit is subjected to vibrations the helical spring, as the vibration amplitude increases, first comes into contact with the part of the spring core situated near the housing. When the vibration amplitude increases further an increasing number of turns of the helical spring come into contact with the spring core, which results in a spring characteristic which is progressive in space directions oriented radially with respect to the helical spring and, consequently, in a progressive damping of the vibration amplitude.

In the advantageous embodiment defined in Claim 4 the spring core is connected to the vibration-sensitive constructional unit and, consequently, vibrates along with the vibration-sensitive constructional unit. The radial clearance between the turns of the helical spring and the spring core in the present embodiment decreases from the housing towards the vibration-sensitive constructional unit, i.e. near the vibration-sensitive constructional unit the clearance between the turns of the helical spring and the spring core is comparatively small, while it is comparatively large near the housing. Therefore, when the vibration-sensitive constructional unit is subjected to vibrations and the vibration amplitude increases, only the turns of the helical spring situated near the vibration-sensitive constructional unit come initially into contact with the spring core. When the vibration amplitude increases further an

increasing number of turns of the helical spring come into contact with the spring core, which results in a spring characteristic which is progressive in a radial direction and, consequently, in a progressive damping of the vibration amplitudes of the vibration-sensitive constructional unit.

The embodiments of the electronic apparatus in accordance with the invention are suitable for use in apparatuses for playing back or inscribing optical storage discs, such as for example CDs or DVDs. The electronic apparatus in accordance with the invention is particularly suitable for mounting in motor vehicles because the mounting room in motor vehicles is limited and numerous vibrations of different frequencies occur during the ride.

Some embodiments of the invention will be described in more detail, by way of example, with reference to Figures 1 to 4 of the drawing. In the drawing:

Figure 1 is a plan view of an electronic apparatus having a vibration-sensitive constructional unit which is coupled to the housing of the electronic apparatus by means of four spring arrangements,

Figure 2 shows a spring arrangement comprising a cylindrical helical spring having non-linearly spaced turns, a conical spring core secured to the housing being disposed inside the cylindrical helical spring,

Figure 3 shows a spring arrangement comprising a cylindrical helical spring having non-linearly spaced turns, a conical spring core secured to the vibration-sensitive constructional unit being disposed inside the cylindrical helical spring,

Figure 4 shows a spring arrangement comprising a conical helical spring having non-linearly spaced turns, a conical spring core secured to the housing being disposed inside the conical helical spring.

Figure 1 is a plan view of an electronic apparatus having a housing 1, which accommodates a vibration-sensitive constructional unit 2. The vibration-sensitive constructional unit 2 is coupled to the housing 1 by means of four spring arrangements 3. The spring arrangements 3 each comprise a cylindrical helical spring 4. The cylindrical helical springs 4 have non-linearly spaced turns, as a result of which progressive spring characteristics are obtained in the directions of the longitudinal axes of the cylindrical helical springs 4. The cylindrical helical springs 4 each have one end secured to the housing 1 and another end to the vibration-sensitive constructional unit 2. The conical spring core 5 is fixedly connected to the housing 1. The end of the conical spring core 5 is slightly spaced from the vibration-sensitive

constructional unit 2, as a result of which a vibration clearance S is available for the vibration-sensitive constructional unit 2. The spring arrangements 3 serve to provide isolation from external vibrations and/or shocks between the housing 1 and the vibration-sensitive constructional unit 2.

Figure 2 shows the spring arrangements 3 arranged between the housing 1 and the vibration-sensitive constructional unit 2 to an enlarged scale. The individual turns of the cylindrical helical spring 4 are spaced apart non-linearly. In the present example the spacing between the turns in a central portion of the helical spring 4 is larger than in the end portions of the helical spring 4. As a result of this, a progressive spring characteristic is obtained in the direction of the longitudinal axis Z of the helical spring 4. The spring core 5 has a conical taper and converges in a direction from the housing 1 towards the vibration-sensitive constructional unit 2. As a result of this, it is achieved that the radial clearance d in a radial direction r between the individual turns of the helical spring 4 and the spring core 5 increases in a direction from the housing 1 towards the vibration-sensitive constructional unit 2.

When the housing 1 is subjected to vibrations the turns of the helical spring 4, as the vibration amplitude increases, first come into contact with the conical spring core 5 in the proximity of the housing 1. As the vibration amplitude increases further an increasing number of turns of the helical spring 4 come into contact with the spring core 5. This results in a progressive damping of the vibrations of increasing vibration amplitude by means of the spring arrangements 3 and, consequently, in a progressive spring characteristic in a radial directions r. Thus, the spring arrangements 3 have an overall progressive spring characteristic in all three directions in space.

In the case of excitation by vibrations of comparatively low frequency the vibration amplitudes of helical springs are larger than in the case of excitation by vibrations of comparatively high frequency. The required vibration clearance S should therefore be adapted to the lowest excitation frequencies that occur in operation. The electronic apparatus shown in Figure 1 is preferably a CD or DVD apparatus intended for use in a motor vehicle. In a motor vehicle the mounting volume available for such an apparatus is intrinsically limited. As a result of the progressive spring characteristics of the spring arrangements 3 the vibration amplitude for the lowest vibration frequency, which dictates the mounting volume, is reduced, thereby allowing the vibration clearance S and thus the overall mounting volume for the housing 1 to be reduced in comparison with that for arrangements having linear spring characteristics.

Figure 3 shows an alternative spring arrangement 6 comprising a cylindrical helical spring 7. This spring arrangement 6 can also be used for the isolation between the housing 1 and the vibration-sensitive constructional unit 2 as shown in Figure 1. The cylindrical spring 7 is fixedly mounted between the vibration-sensitive constructional unit 2 and the housing 1. A conical spring core 8 is arranged inside the cylindrical helical spring 7 but, instead of being fixed to the housing 1 as in the arrangement shown in Figure 2, it is fixed to the vibration-sensitive constructional unit 2. The conical spring core 8 thus vibrates along with the vibration-sensitive constructional unit 2. The spring core 8 tapers down conically from the constructional unit 2 in accordance with the invention towards the housing 1. As a result of this, the radial clearance d in the direction r between the turns of the helical spring 7 and the conical spring core 8 decreases from the housing 1 towards the vibration-sensitive constructional unit 2. A consequence of this is that, when the vibration-sensitive constructional unit is subjected to vibrations, initially the turns of the helical spring 7 situated near the vibration-sensitive constructional unit 2 come into contact with the spring core8. When the vibration amplitude increases further, the turns of the helical spring which are further away from the vibration-sensitive constructional unit 2 also come into contact with the spring core 8, which again results in a progressive spring characteristic and, consequently, in a progressive damping of the vibrations of the vibration-sensitive constructional unit 2 in the radial direction r. In the z direction the progressive spring characteristic of Figure 2 is obtained in that the spacing between the individual turns of the helical spring 7 in the central portion of the helical spring 7 is larger than in the end portions of the helical spring 7. Thus, a progressive spring characteristic in all three directions in space is also obtained for the spring arrangement shown in Figure 3.

Another alternative spring arrangement 11 for the isolation between the housing 1 and the vibration-sensitive constructional unit 2 shown in Figure 1 is shown diagrammatically in Figure 4. A conical helical spring 9 is interposed between the housing 1 and the vibration-sensitive constructional unit 2 and has one of its ends secured to the vibration-sensitive constructional unit 2 and its other end to the housing 1. The spacing between the turns of the conical helical spring 9 in the z direction is non-linear, which is achieved in that the spacing between the turns is made larger in the central portion of the conical helical spring 9 than in the end portions of the conical helical spring 9. The radial diameter in the radial direction r of the conical helical spring 9 decreases in a direction towards the housing 1, i.e. it is larger in the proximity of the vibration-sensitive constructional unit 2 than in the proximity of the housing 1. A conical spring core 10, secured to the housing

1, is arranged inside the conical helical spring 9. The conical spring core 10 tapers towards the housing 1. The degree of taper of the conical spring core 10 is such that the radial clearance d between the turns of the helical spring 9 and the spring core 10 increases from the housing 1 in a direction towards the vibration-sensitive constructional unit 2. This results in a progressive characteristic of the spring arrangement of Figure 4 in the radial direction r. Thus, a progressive spring characteristic is obtained in all three directions in space.

Further spring arrangements having wide variety of springs and spring cores are conceivable, which also lead to a progressive spring characteristic. The only essential feature for all possible spring arrangements is that the clearance between the turns of the helical spring and the spring core situated inside the helical spring is not constant, in such a manner that an increasing number of turns of the helical springs come into contact with the spring cores as the vibration amplitude of the vibration-sensitive constructional unit 2 increases.

CLAIMS:



1. An electronic apparatus having a vibration-sensitive constructional unit (2) accommodated in a housing (1), the housing (1) and the vibration-sensitive constructional unit (2) being coupled by damping means (3, 6, 11), characterized in that the damping means comprise at least one spring arrangement (3, 6, 11) having a progressive spring characteristic, particularly a spring characteristic which is progressive in three directions in space.

2. An electronic apparatus as claimed in Claim 1, characterized in that the spring arrangement (3, 6, 11) comprises a helical spring (4, 7, 9) having non-linearly spaced turns, and in that a spring core (5, 8, 10) is arranged inside the helical spring (4, 7, 9), the helical spring (4, 7, 9) and the spring core (5, 8, 10) being constructed in such a manner that the radial clearance between the turns of the helical spring (4, 7, 9) and the spring core (5, 8, 10) is not constant.

3. An electronic apparatus as claimed in Claim 2, characterized in that the spring core (5, 10) is secured to the housing (1) and in that the radial clearance (d) between the turns of the helical spring (4, 9) and the spring core (5, 10) increases from the housing (1) in a direction towards the vibration-sensitive constructional unit (2).

4. An electronic apparatus as claimed in Claim 2, characterized in that the spring core (8) is secured to the vibration-sensitive constructional unit (2) and in that the radial clearance (d) between the turns of the helical spring (7) and the spring core (8) decreases from the housing (1) in a direction towards the vibration-sensitive constructional unit (2).

5. An electronic apparatus as claimed in any one of the Claims 1 to 4, characterized in that the spring is a conical helical spring (9) having non-linearly spaced turns.

6. An electronic apparatus as claimed in any one of the Claims 1 to 4, characterized in that the spring is a cylindrical helical spring (4, 7) having non-linearly spaced turns.

7. An electronic apparatus as claimed in any one of the Claims 1 to 6, characterized in that the apparatus is an apparatus for reading information stored on an optical storage disc and/or writing information on an optical storage disc, particularly a CD/DVD apparatus.

8. An electronic apparatus as claimed in any one of the Claims 1 to 7, characterized in that the electronic apparatus is adapted to be built into a motor vehicle.

9. A motor vehicle equipped with an electronic apparatus as claimed in any one of the Claims 1 to 8.