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~~Energy Guiding Chain with Wear Detection~~

~~Amended claims~~Claims

1. An energy guide chain (1) with wear detection, comprising a number of chain links, which are configured for protected guidance of lines, such as cables, hoses or the like, between a first connection end (F) and a second connection end (M) movable relative thereto, wherein each chain link has at least one link plate (5) and link plates (5) of adjacent chain links are each connected together in the longitudinal direction (L) by an articulated joint, in particular with nominal swivel axis (A), which in particular in each case comprises a pin (6A) and a corresponding receptacle (6B), and at least one detection unit (10, 20, 30, 40, 50, 120) for detecting wear on at least one chain link,
characterized in that
the at least one detection unit (10, 20, 30, 40, 50, 120) comprises a first electrical component (11, 41, 51, 121), which is attached with predetermined orientation to a first chain link, and a second electrical component (12, 42, 52, 122), which is attached with predetermined orientation to an adjacent second chain link that is articulatedly connected to the first chain link, wherein the components interact in contactlessly coupled manner, in particular

inductively, magnetically or capacitively, to sense a change in the coupling in the event of wear-related occurrence of radial and/or axial play in the articulated joint between first and second chain link.

2. The energy guide chain (1) as claimed in claim 1, **characterized in that** the at least one detection unit (120) comprises as components a magnet (122) and a Hall element (121) interacting with the magnet (122).

3. The energy guide chain (1) as claimed in claim 1, **characterized in that** the at least one detection unit (10, 20, 30, 50) comprises a first coil (11, 51) as first component and a second coil (12, 52) as second component.

4. The energy guide chain (1) as claimed in claim 3, **characterized in that** the first (11, 51) and second (12, 52) coils, preferably embodied as flat coils, are arranged opposite one another coaxially with the nominal swivel axis (A) of the articulated joint; or the first (11, 51) and second (12, 52) coils are embodied as cylindrical coils, which are oriented perpendicular to a nominal swivel axis (A) of the articulated joint.

5. The energy guide chain (1) as claimed in claim 3 or 4, **characterized in that** the two coils (11, 51, 12, 52) have at least one associated magnetic core (15), which is preferably attached to the first or second chain link coaxially relative to the nominal swivel axis (A).

6. The energy guide chain (1) as claimed in claim 1, **characterized in that** the at least one detection unit (40) comprises a first electrode (41) as first component and a second electrode (42) as second component, wherein the electrodes (41, 42) each have an axis of symmetry, which is arranged coaxially with a nominal swivel axis (A) of the articulated joint.

7. The energy guide chain (1) as claimed in one of claims 1 to 6, wherein, to form the articulated joint between adjacent chain links, each link plate (5) has a pin (6A) at a first end region and a corresponding receptacle (6B) at a second end region, **characterized in that**, in the case of at least two articulatedly connected link plates (5), the first electrical component is arranged on the pin (6A) of the one link plate (5), and/or the second electrical component is arranged on the receptacle (6B) of the other link plate (5).

8. The energy guide chain (1) as claimed in one of claims 1 to 6, in particular as claimed in claim 2, wherein each chain link comprises two opposing link plates (5A, 5B), which define a receiving space for lines, with at least some of the opposing link plates (5A, 5B) being connected by crosspieces (7), **characterized in that** the first component of the at least one detection unit (120) is attached to one of the link plates (5) of the first chain link and the second component of the at least one detection unit (120) is attached to a crosspiece (127) of the second chain link connected articulatedly to the first chain link.

9. The energy guide chain (1) as claimed in claim 8, **characterized in that** the crosspiece (127) has a holder (129) with a retaining arm (131) on which the second component of the detection unit (120) is mounted, wherein the retaining arm (131) extends transversely of the crosspiece (127), in order to position the second component relative to the first component in such a way that the two components may interact to sense wear-related radial and/or axial play in the articulated joint.

10. The energy guide chain (1), in particular roller chain for long travel paths, as claimed in one of claims 1 to 9, wherein the link plates (5) are embodied as offset link plates with pin (6A) and corresponding receptacle (6B), **characterized in that** at least some link plates (5) have rollers (8) to allow the energy guide chain (1) to roll; and/or at least some link plates (5) have a first recess coaxial with the pin (6A) for the first component.

11. The energy guide chain (1) as claimed in one of claims 1 to 6, wherein each chain link comprises two link plates (5A, 5B), the link plates (5A, 5B) forming opposing strings of plates which define a receiving space, and the strings of plates being held in parallel at at least every second chain link by crosspieces (7) connecting the link plates (5A, 5B), **characterized in that**, in the case of at least two articulatedly connected link plates (5), an internal part (123) is in each case attached in the receiving space between the crosspieces (7), wherein the internal parts (123) have two axially opposing end

regions (124, 125) on the nominal swivel axis (A) of the articulated joint of the link plates (5) and at the end region (124, 125) of the one internal part (123) the first component is attached and at the end region (124, 125) of the other internal part (123) the second component is attached.

12. The energy guide chain (1) as claimed in one of the preceding claims 1 to 11, **characterized in that** in a longitudinal portion a number of successive chain links in each case have a first electrical component and a second electrical component, wherein in particular a serial cascade consisting of a number of detection units (10; 20; 30; 40; 50; 120) is provided.

13. The energy guide chain (1) as claimed in claim 12, **characterized in that** the components are embodied as coils (11, 12), and the coils of a link plate (5) have an unequal number of turns, in particular with a turns ratio which at least partly compensates voltage losses in the cascade.

14. The energy guide chain (1) as claimed in claim 2, **characterized in that** the detection unit (120) has an electronic circuit (133) and the magnet (122) brings about a Hall voltage in the Hall element (121) which is measurable by the electronic circuit (133), in order for the electronic circuit (133) to sense a wear-related change in the relative position of the magnet (122) with regard to the Hall element (121), wherein the magnet (122) preferably has an axis of symmetry which is arranged coaxially with the nominal swivel axis (A) of the articulated joint and the Hall

element (121) is arranged eccentrically relative to this axis of symmetry.

15. The energy guide chain (1) as claimed in claim 14, **characterized in that** the magnet (122) is attached to one of the link plates (5) of the first chain link, in particular in a receptacle (6B) of the articulated joint, and the Hall element (121) is attached to a crosspiece (127) of the second chain link, in particular to a retaining arm (131) of the crosspiece (127) extending transversely of the crosspiece.

16. A detection system having an energy guide chain as claimed in one of the preceding claims, **characterized in that** an evaluation unit (90) is connected for signal evaluation with the at least one detection unit (10; 20; 30; 40; 50; 120), in particular with each detection unit (10; 20; 30; 40; 50; 120).

17. The detection system as claimed in claim 16, **characterized in that** the evaluation unit (90) supplies the detection unit(s) (10; 20; 30; 40; 50) with a reference voltage, in particular AC voltage, on the input side, in order to pick off an output signal on the output side and/or has a memory with a stored setpoint range for nominal operation and compares an electrical signal picked off from the detection unit, in particular from a plurality of cascaded detection units, preferably after filtering, with the setpoint range.

18. A link plate (5, 5A, 5B) for an energy guide chain (1) with wear detection, with a pin (6A) and a

corresponding receptacle (6B) for forming articulated joints each with a nominal swivel axis (A) between successive chain links **characterized in that** a first electrical component is attached in the region of the pin (6A) with a predetermined orientation relative to the nominal swivel axis (A), in particular coaxially with the pin (6A), and a second electrical component is attached in the region of the receptacle (6B) with a predetermined orientation relative to the nominal swivel axis (A), in particular coaxially with the receptacle (6B).

~~19. A crosspiece (127) for an energy guide chain (1) with wear detection, **characterized in that** the crosspiece (127) has a holder (129) for a detection unit (120) comprising an electronic circuit for wear detection, wherein the holder (129) comprises a retaining arm (131), which extends perpendicularly to the longitudinal extent of the crosspiece (127) and which at the end has an electrical component (11, 41, 51, 121), in particular a Hall element (121), of the detection unit (120), for attachment of the component of the detection unit in a predetermined spatial position in the receiving space of the energy guide chain.~~

~~20. An arrangement for an energy guide chain (1) with wear detection, comprising a pair of chain links of an energy guide chain (1) connected together by an articulated joint, with in each case two link plates, which are held parallel by crosspieces connecting the link plates, and with in each case one internal part (123) attached between the crosspieces (7) in each of~~

the two chain links of the pair, wherein the two internal parts (123) have interacting conjugate end regions (124, 125) which are arranged opposite one another axially relative to a nominal swivel axis of the articulated joint of the two interconnected chain links, wherein a first component is attached to one end region (124, 125) of the one internal part (123) and a second component is attached to the end region (124, 125) of the other internal part (123), wherein the components are capacitively or inductively coupled in order to be able to identify a change in the coupling in the event of wear-related occurrence of radial and/or axial play in the articulated joint between the two chain links.

21. The arrangement as claimed in claim 20, characterized in that the one and/or the other internal part in each case has two attachment regions for top and bottom attachment to the crosspieces.