



DESCRIPTION

The invention relates to a magnetic aerial in accordance with the definition of the species of claim 1.

Such an arrangement is known from US-A 3,032,651. There, besides the works, a simple detector receiver is provided in the casing of a wristwatch. Hinged in a spring-elastic manner to the casing is a strap in the form of two curvedly extending stiff clips which have cavities for the reception of batteries or respectively of a loudspeaker and a magnetic aerial consisting of a ferrite core surrounded by a coil. The ferrite core is a rigid body which is adapted in a kidney-shaped manner to the cross-section of the cavity geometry, in which respect the axis of the core and of the aerial coil extends transversely to the longitudinal extent of the strap clip curve and thus the length of the core is restricted to its width directed at the watch casing. For the connection of the aerial coil to the receiver in the wristwatch casing, a flexible cable extends along the clip curve across the hinge thereof into the housing. Such a design does not allow a flat and flexible wristwatch having a functionally reliable connection of the aerial coil to the receiver circuit to be realised.

This applies accordingly to the accommodation of a series connection of resonance filters in the watch strap, as is known from EP-A 0 100 639.

From the Patent Abstracts of Japan, Vol. 7, No. 190 (E-194) [1335] 19.8.1983; & JP-A 58 094204 (DAINI SEIKOSHA K.K.), 4.6.1983 it is known 'per se' to use a flexibly layered core for a ferrite aerial.

On the other hand, the problem underlying the invention is to develop further an aerial of the type in accordance with the species in such a way that it can be used as a high-performance long-wave aerial for radio wristwatches having flexible straps.

This is because, for the receiver of a radio-controlled clock, as is described in more detail in EP-A 0 242 717, a long-wave aerial of sufficient power is needed for the reception of items of time information transmitted by radio. The realisation of such a radio-controlled clock as a wristwatch has hitherto been considered by the experts already on account of the space requirement for the construction of the radio receiver as not being realisable (see R. Bernbach and M. Lobjinski "Neue Funkuhren aus dem Institut für Datentechnik" in FUNKUHREN, published by W. Hilberg, middle of page 170); in which respect there the difficulty of the accommodation of an adequate magnetic-core frame-aerial volume for a high-performance long-wave aerial is not even taken into consideration. The space requirement for the receiver is meanwhile solved, since there are fixedly-tuned long-wave receivers, integrated on a chip, for



radio-controlled clocks (see DE-A 35 16 810). What was hitherto unsolved was, however, the problem of the miniaturisation of sufficiently efficient passive aerials for long-wave receivers, which e.g., as in the case of modern consumer radio-controlled clocks, are intended to be operated from a single-cell battery, especially when they are intended to be accommodated in the strap of a wristwatch and this strap is intended in the conventional manner to remain a flexible strap.

The above problem is solved, in accordance with the invention, in that the magnetic aerial in accordance with the species is additionally designed in accordance with the characterising part of claim 1.

This solution is based on the consideration that a considerable impediment to the realisation of a suitable frame aerial is not so much the volume of the (ferrite) core penetrating the frame coil, as rather the space requirement for the necessary core volume. In accordance with the solution according to the invention, a flexibly held core for a frame aerial is provided, as can be realised in known 'per se' manner by a layered structure, in which respect now, however, mutually displaceable flexible strips are realised from mild-magnetic materials of high permeability, such as in particular amorphous metals in leaf form. Such a magnetic aerial is now inserted as a strap aerial of a radio-controlled wristwatch into the flexible watch strap.

For the electrical connection of the coil of such a flexible frame aerial, advantageously a structure consisting of multilayer conduction foils bonded onto insulating material foils is used, in the centre of which there extends a relatively narrow conductor, which experiences an electrical shielding by wider conduction foils which extend thereabove and therebelow and which can at the same time serve as return leads of the aerial connection to the radio-controlled clock receiver. Such an electrically tunable flat-band lead is advantageously bonded in front of the aerial coil onto the core, in which respect, in the connection region to the coil connection wires, a miniaturised balancing capacitor for the aerial resonant circuit can equally also be applied. The opposite end of the flat-band lead is equipped with plug-in means, which are preferably directed approximately transversely to the longitudinal extent and thus transversely to the traction direction of the flat-band lead entering into a watch casing and are fitted together there with complementary plug-in means for the connection to the receiver in the watch casing. A soft elastic cast-around surround of the aerial core with its coil advantageously also encompasses the course of the flat-band lead as far as the plug-in means positioned in the watch casing, so that a clamp securing of the strap surround at the entry into the watch casing at the same time serves for the mechanical fastening and the moisture sealing of the plug-in connectors.

The capacitance for the oscillatory circuit tuning of the aerial coil can be integrated into the layered structure, by for example individual layers which are anyway electrically mutually insulated - to avoid eddy current losses - being connected together as reciprocal electrode groups to form the capacitance and being connected in parallel with the aerial coil.

With respect to additional alternatives and further developments, reference is made to the further claims. Further advantages of the invention will also become apparent from the following description of preferred examples of realisation with regard to the solution in accordance with the invention which are depicted in the drawings along with a restriction to that which is essential in an abstracted manner, in particular enlarged and distorted not true-to-scale, for the case of strap aerals which can be connected to a wristwatch casing.

- Fig. 1 shows in interrupted axial longitudinal section a flexible magnetic aerial in a design as a radio-controlled watch strap,
- Fig. 2 shows in highly condensed cross-sectional representation a strap aerial in accordance with Fig. 1 taking into account an aerial flat-band lead resting on the strip core in front of the front end of the coil,
- Fig. 3 shows the flat-band lead in accordance with Fig. 2 in interrupted and fragmentary top-view representation, with the cast-around surround being omitted and with the upper shielding conduction foil together with the insulating foil arranged thereunder being omitted and without taking into account the tuning capacitor mounted in the coil connection region,
- Fig. 4 shows in fragmentary longitudinal sectional representation the clamp fastening of the strap surround to the edge of a watch casing with plug-in means, directed transversely to the tensile stress direction, for the electrical connection of the works receiver to the aerial flat-band lead,
- Fig. 5 shows in a strap detail a core also flexibly surrounded transversely to its longitudinal extent and
- Fig. 6 shows a relatively stiff core in the connection between flexible strap parts.

An autonomous radio-controlled (wrist) timepiece 11, shown only symbolically in the drawings of the type explained in more detail above is equipped with a radio receiver 12 for receiving and decoding items of time information which if necessary serve for correcting the time currently indicated by the radio-controlled timepiece 11. The receiver 12 is fed from an aerial 13 designed as an L-C-oscillatory circuit. This is constructed as a layered-core frame aerial, thus from a coil 14 which is penetrated by a flexible core 15.

The core 15 is preferably layered as an elongate stack of very thin strips 16 of amorphous mildly-magnetic highly permeable material, as are marketed for instance under the trade name of VITROVAC by Messrs. Vacuumschmelze GmbH (D-6450 Hanau) as extremely thin and spring-hard-flexible sheets in particular for the construction of low-loss transmitters in switching power supplies and for magnetic switches of pulse current supplies and which are distinguished by low sensitivity to mechanical stresses.

This core 15 is gripped transversely to the surface extent of its strips 16 by a surround 17, as symbolised in the drawings by the stretching direction triangles. This surround 17, for example designed as a plastics sheath sprayed around the core 15, advantageously also covers the coil 14, in order to fix it positionally on the core 15 and to protect it mechanically against environmental influences. If the surround 17 is flexible, in order to give different geometric shapes to the aerial 13 - for example for installation in restricted space conditions or for design as a strap - the axial length 18 of the coil 14 is relatively restricted, in order to keep as small as possible the region of the non-pliant core 15 which is stiffened by the applied coil 14. On the other hand, a coil 14 which towers radially as little as possible above the core 15 is already for electromagnetic reasons to be striven after, because the field intensity decreases quadratically over the distance from the core 15, thus further remotely lying winding layers of the coil 14 experience only very slight contributions from the field-reinforcing effect of the core 15. Advantageously the coil 14 is even introduced into a core constriction 48, as is taken into account in Fig. 5 and Fig. 6.

Likewise in the interests of the flexibility of a stack core 15, in front of the front ends, on both sides, of the strips 16, vis-a-vis the surround 17 enclosing these, a free space 19 is left. In this way a longitudinal displacement of individual strips 16 mutually is made possible if the core 15 is curved about its longitudinal axis.

If, instead of this or additionally, flexibility of the aerial strap 28 transversely to the longitudinal extent of the strips 16 is desired, the core 15 (Fig. 5) consists of individual or stacked strips 16 in frontal sequence in front of one another, with engagement of convexly rounded front ends 49 respectively into concavely adapted joint cavities 50 of the adjacently adjoining strip 16. The strips 16 (or those thereof situated on the outside) can, however, also be replaced by a filling 51 of soft-ferrite powder in the associated part of the pliant surround 17 in the course of the strap 28. If it is not so much a matter of flexibility in the direction of the longitudinal axis, the individual joint part strips 16 preferably consist of (sintered) ferrite.

If a relatively stiff core 15 is afforded, for instance

realised as a single-layer or multi-layer ferrite body, then it can for aesthetic reasons be advantageous to fashion it in its surround 17 geometrically to a certain extent as an optical counterpart to the watch 11 itself (Fig. 6) and to design it in anatomical adaptation to an arm curved as a ring sector. The connection to the watch 11 is then effected by way of partial straps 28-28, which can be connected to the aerial core 15 by way of fasteners or joint members 29.

In order, upon mutual parallel displacement of stacked strips 16 of a flexible core 15, to avoid abrasion phenomena as far as possible, and in order at the same time to reduce electromagnetic eddy current losses in the ferrite core 15, the individual layers of the strips 16 are separated from one another mechanically and electrically by interpolated insulating layers 20, for instance foils or layers of varnish.

For this insulation 20 advantageously a flexible material having a high dielectric constant is used, as is available on the market for instance as the so-called X7R ceramic for the construction of small layered capacitors of high capacitance. If the core 15 is also to be bent with small radii, current dielectrics such as mica or foils of polyester or respectively polycarbonate and the like are more advantageous.

This insulation material can be coated or covered with electrically conductive electrodes, in order to integrate the resonance capacitance 21 equally also into the strip-stack aerial 13 and to connect it electrically within the protective surround 17, for example by way of welded joints 22, up to the ends of the coil 14. This reduces the capacitance value and thus the installation space requirement of an external tuning capacitor 23, if this cannot even be completely dispensed with as a result of the integrated resonance capacitance 21.

Even the electrically conductive core strips 16 themselves can serve as the capacitor electrodes on both sides of dielectric insulating foils 20, so that the additional interleaving of separate capacitor electrodes on both sides of the insulating foils 20 is superfluous. As is known 'per se' from the technology of layered capacitors, these electrode strips 16 are, in the interests of a large effective electrode surface and thus of a high capacitance value, connected together by turns in such a way with one another that the result is electrode groups 24.1, 24.2 alternately intermeshing in a comb-shaped manner. Of these, respectively the external strip 16.1 or 16.2 can serve as conductor path for the fastening of the coil connectors 22.1, 22.2 to outwardly leading aerial connections 25.1, 25.2. As a result of flexible wirings 26.1, 26.2 between the electrode strips 16 of the electrode groups 24 in the region of the associated free spaces 19.1, 19.2 the reciprocal axially parallel displaceability of the strips 16 mutually upon bending stress of the ferrite core 15 remains ensured.

The aerial 13 consisting of coil 14 with core 15 as well as possibly resonance capacitance 21 can be connected by way of leads 27 to the radio receiver 12 of the clock 11, in the casing of which this aerial 13 is inserted. If it is a matter of a portable radio-controlled clock 11 and in this respect in particular of a design as a wristwatch, the flexible aerial 13 is, as a result of its surround 17, advantageously likewise designed as a strap 28, as shown in the drawings by joint members 29.

These can be connected directly - or if necessary by way of interpolated extension members - to the hornlets of a wristwatch casing if these hornlets are mutually electrically insulated, so that additional connection leads (27) are superfluous. However it is already sufficient to design one strap half or an intermediate piece of a strap 28 as an aerial 13. In order to be able to exchange defective straps 28 easily and economically, provision can also be made for designing the aerial 13 as or on a sheath-shaped flexible hollow body, through which the replacement strap 28 is threaded, without also having to exchange the aerial 13 and balance the receiver 12 or its aerial oscillatory circuit anew.

Thus, a radio-controlled (wrist) timepiece 11 is realisable upon the dimensional shaping or design of which consideration no longer has to be shown for installation space requirement for a receiving aerial 13. Such a layered aerial designed as a strap 28 or arranged on a strap yields an astonishingly high performance, compared with conventional cylindrical ferrite cores as coil carriers, because the aerial voltage is proportional to the core cross-section and above all to the (here very great) permeability of the core material, as well as approximately proportional to the core length and approximately inversely proportional to the core thickness. The core 15 carrying the coil 14 can, however, on account of the high permeability be of small thickness, with, in the interest of good flexibility of the strap 28, great axial length of the core 15 in relation to the magnetically effective thickness of the core strips 16 stacked one on top of the other as such.

Possibly the electrical connection, shown in Fig. 1, of the aerial 13 to the receiver 12 by way of strap joint members 29 to the watch casing is, however, not sufficiently reliable, for instance by reason of movements or deposits of dirt between the joint members. Even freely conducted leads 27 can be aesthetically or electrically disturbing, especially since they have to be equipped with plug-in connectors for the connection to the watch casing, which along with considerable constructional expenditure would have to be designed in a moisture-tight manner.

What would be aggravating, in addition to this, would be the fact that such aerial connection leads 27 between the receiver 12 and the magnetic aerial 13 would have to be

shielded in design, in order to avoid stray interference effects.

Therefore it is more advantageous to realise the electrical function of the leads 27 or respectively of the contact joint members 29 in accordance with Fig. 2 to Fig. 4 and Fig. 6 by a multi-layer flat-band lead 31 balanced electrically to the aerial oscillatory circuit, for instance in the manner of the backed multi-layer foils as are marketed for instance by Messrs. DuPont under the trade name of PYRALUX.

The construction is now, however, such that at least one narrow conductor 32 is arranged electrically insulated in sandwich manner between two outer wide conduction foils 33. These conduction foils 33 project at both longitudinal edges approximately by the width of the narrow conductor 32 lying in the centre laterally beyond this, so that the result is a good shielding effect of the outer conduction foils 33 for the conductor 32 lying in the interior. The narrow conductor 32 and the conduction foils 33 are advantageously designed as metallic facings on insulating plastics carrier foils 34.

In the interests of a connection which is simple to produce but durable, the entirety of this layered structure of the flat-band lead 31 in the region in front of the front end 35 of the coil is fastened to the surface of the flexible strip core 15 penetrating the coil 14 by means of an insulating adhesive layer 36. In this respect, there are recesses at the connection end 37 (see Fig. 3) of the flat-band lead 31 in the upper shielding conduction foil 33' (omitted for the representation of Fig. 3) and in the insulating foil 34" above the lower conduction foil 33", in order to be able to connect here the coil connection wires 22 to the central conductor 32 and to the lower shielding foil 33" serving as return lead. If a tuning capacitor 23 is necessary for the aerial tuning, it is advantageously likewise arranged in this connection region between the flat-band lead 31 and the aerial coil 14, for instance connected as a surface-assembly chip capacitor conductively between the conductor 32 and the conduction foil 33".

The sprayed-around aerial surround 17 then also surrounds this connection, equipped with the capacitor 23, of the flat-band lead 31 to the aerial coil 14 on the surface of the flexible aerial coil 15.

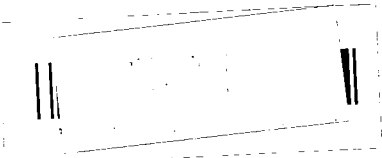
In front of the core end 37 the flat-band lead 31 can, as taken into account in Fig. 3, first of all in the interests of high bending stressability emerge with a constant width, in order then to merge into a more flexurally pliant zone of a lead constriction 38. This ends finally in a connection region 39, widened again, with a lead lug 40 in the region of a conduction-foil recess 41 and a pair of lugs 42 through the conduction foils 33 on both sides of this recess 41. Plug-in means 43 (plug sockets or plug pins) are inserted into these lugs 40, 42, in order (see Fig. 4), in the case of a plug-in

direction transversely to the longitudinal extent of the flat-band lead 31, to be able to be connected mechanically and electrically in the edge region for instance of a wristwatch casing 44 to connection conductors 45, kept insulated there, to the radio-controlled clock receiver 12.

Provided for this aerial connection by way of the flat-band lead 31 is a casing clamp connection 46 for the moisture-tight compression retention of the elastic cast-around surround 17, which with the connection region 39 of the flat-band lead 31 ends in a connection cavity 47. Arranged in this in insulated manner are housing-fast counter-contacts to the plug-in means 43 in the flat-band lead lugs 40, 42. Thus the result is a moisture-tight and mechanically highly stressable electrically high-grade aerial connection to the receiver 12 in, for example, a wristwatch casing 44.

Not separately executed in the drawings is an advantageous additional measure for the compensation of the variation of the inductance by reason of the relative permeability of the core material upon mechanical (bending) stress in the sense of the retuning of the thereby varied circuit frequency. For this, in the receiver 12 a balancing control can act on the oscillatory circuit capacitance, for instance by means of a switchable capacitance cascade or by way of the corresponding control of a capacitance diode.

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CLAIMS

1. A magnetic aerial (13), with a ferrite core (15) which penetrates a coil (14), in the strap (28) of a wristwatch (11), the coil (14) being connected to a receiver (12) in the wristwatch (11), characterised in that as a long-wave aerial (13) the ferrite core (15) is stacked from flexible thin strips (16) of highly permeable metal, is of great axial length in relation to the magnetically effective thickness of the strips stacked one on top of the other and is encompassed by the strap (28), which is flexible and also covers the coil (14), in front of the one front end (35) of which a flat-band lead (31) which is equipped in the connection region with a tuning capacitor (23) and which is fastened to the ferrite core (15) is connected to the coil (14), which likewise extends in the strap (28) and has in its centre region a conductor (32), on both sides of which there extend conduction foils (33) which are connectable as return leads, in which respect the flat-band lead (31) at the opposite end to the connection to the coil (14) has plug-in means (43) for the connection of the tuned aerial (13) by way of the edge of the casing (44) of the wristwatch (11) to a radio-controlled clock receiver (12) contained therein.

2. A magnetic aerial according to claim 1, characterised in that provided in front of the strip front ends of the stacked ferrite core (15) is a free space (19) for mutual longitudinal displacements of the flexible strips (16) stacked one above the other.

3. A magnetic aerial according to claim 1 or 2, characterised in that arranged between the strips (16) are insulations (20) made of material having a high dielectric constant, on both sides of which electrodes of a resonance capacitance (21) connected in parallel with the coil (14) are provided.

4. A magnetic aerial according to claim 3, characterised in that the electrodes of the resonance capacitance (21) are the magnetic material strips (16) themselves.

5. A magnetic aerial according to any one of the preceding claims, characterised in that the tuning capacitor (23) is designed for compensation of a circuit frequency change by reason of mechanically occasioned permeability change of the ferrite core (15).