

This invention relates to a device for converting the rotary motion of an eccentric driven by a motor shaft into a reciprocating motion of a tool, coupled with a pin, of electrically powered small appliances having pivotally mounted in their housings a two-armed lever provided with the pin and a connecting rod connecting the two-armed oscillating lever with the eccentric, with the connecting rod being coupled with the eccentric by means of a pivot bearing.

DE-C-24 09 592 discloses a dry shaving apparatus with a rotating motor, an oscillating lower cutter and a crank-and-rocker mechanism for converting the rotary motion of the motor into the oscillating motion of the lower cutter, with the motor shaft being aligned parallel to the longitudinal axis of the oscillating lever engaging into the lower cutter and being laterally offset by an amount corresponding to the length of the connecting rod. The connecting rod has its one end connected with the eccentric on the motor shaft by means of an elastic Cardanic suspension comprised of a pivot bearing and elastic members, while its other end is connected with the oscillating lever through a ball-and-socket joint to transmit the eccentric motion to the oscillating lever while at the same time compensating for and adapting to the directions of motion of the connecting rod and the oscillating lever. This type of motion transmission is expensive and extremely problematic in terms of manufacturing because of the tolerance requirements of the bearings and the members of the joint. The amount of useful power which is destroyed by the motion-transmitting device is very high. The vibratory response of the oscillating lever in which a constant amplitude is aimed at as optimum within a predetermined speed range of the rotating motor is very negative.

From JP-Y2 57-57650 a dry shaving apparatus is known having a rotating motor, an oscillating lower cutter and a crank-and-rocker mechanism for converting the rotary motion of the motor into an oscillating motion of the lower cutter. The motor shaft is aligned parallel to the longitudinal axis of the oscillating lever engaging into the lower cutter and is laterally offset by an amount corresponding to the length of the connecting rod. The connecting rod is of fork-shaped configuration in the area of the oscillating lever, with the oscillating lever engaging into the fork and being pivotally held in the fork by means of a pivot pin. The connecting rod is further connected with the motor shaft of the rotating motor through an eccentric drive mechanism provided in

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the head of the connecting rod. In this motion-transmitting arrangement, the amplitude of oscillation of the oscillating lever is compensated for through the connecting rod only by putting up with considerable pressure loads and high frictional forces in the two bearing points, the pivot pin and the eccentric drive mechanism of the connecting rod, whereby a high percentage of the power to be transmitted is destroyed which necessarily has to be generated by an increased supply of energy. The user of such an appliance will become aware of such an increased energy consumption by having to recharge the accumulator or replace the batteries at short intervals, for example, after a low number of shaves.

It is an object of the present invention to provide a device of the type initially referred to in which the conversion of the rotary motion into a reciprocating motion is accomplished at a minimum possible loss of driving energy. Also, the device is to ensure unhindered motion in all required degrees of freedom at low friction and is to operate with a minimum of noise.

In accordance with the present invention, these requirements are satisfied in that the two-armed oscillating lever and the connecting rod are coupled with each other through a joint coupling allowing all rotations and a translation, parallel to the longitudinal axis, of the connecting rod relative to the oscillating lever, and that the pivot center lies in the longitudinal axis of the associated lever arm of the two-armed oscillating lever.

In accordance with the invention, the pivot center coincides with the point of intersection of the longitudinal axes of the associated lever arm of the two-armed oscillating lever and the connecting rod.

The solution of the invention is characterized in particular by a low power consumption and an improved amplitude response over fluctuations in rotational speed, which is attributable to the fact that for the transmission of motion only a single joint coupling is provided uniting in its center all degrees of freedom. This joint coupling between the two-armed oscillating lever and the connecting rod allows all rotations and a translation, parallel to the longitudinal axis of the oscillating lever, of the connecting rod relative to the oscillating lever. This joint coupling which has its center lying in the longitudinal axis of the associated lever arm of the two-armed oscillating lever, in which center all axes of motion of the components executing a

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swivelling movement meet, makes it also possible, due to the ensuing introduction of force in this center, that the rigidity of the two-armed oscillating lever and the connecting rod can be reduced, resulting in a reduction in the total weight of these components. Also, the diameter of the bearing of the two-armed oscillating lever as well as of the bearing pin engaged with the connecting rod can be reduced, resulting in less friction in these bearing points.

It will be understood that a number of different embodiments are possible without departing from the spirit of the present invention, each single embodiment affording additional advantages.

A particularly simple embodiment of the invention affording low-cost manufacture is characterized in that a bearing pin extending in the direction of the longitudinal axis of the two-armed oscillating lever is provided on the lever arm cooperating with the connecting rod, that the rigid connecting rod has at its one end a bearing bore of relatively thin wall thickness surrounding the bearing pin with a predetermined clearance therebetween, that the bearing pin is provided with a stop means against which the connecting rod abuts, and that both the stop means and the area around the bearing bore are formed such as to ensure an unhindered rolling action in the contact area in all directions of motion of connecting rod and two-armed oscillating lever.

In a variation of this embodiment, the stop means on the bearing pin as well as the connecting rod are of rounded configuration in the area of the bearing bore, with the rounding of the connecting rod being conformed to the rounded contours of the stop means.

The joint coupling embodying the above-identified features ensures that the axes of motion of connecting rod and two-armed oscillating lever meet directly in the pivot center lying in the longitudinal axis of the oscillating lever.

Another embodiment is characterized in that the connecting rod is pivotally mounted on the associated lever arm of the two-armed oscillating lever about the longitudinal axis thereof, and that the connecting rod includes at least one pair of joints/film hinges whose center/bending axis intersects the longitudinal axis of the associated lever arm of the two-armed oscillating lever. In this embodiment, the located center/bending

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axis of the connecting rod which extends through the pivot center ensures that the axes of motion of the connecting rod are directed to the pivot center indirectly.

In a variation of the last-mentioned embodiment, the connecting rod has a fork-shaped end, the prongs of the connecting rod are interconnected by a cross piece, the cross piece is provided with an arm which extends into the opening between the prongs and includes a bearing bore, and the prongs of the fork are each provided with a film hinge whose common center/bending axis intersects the center axis of the bearing bore.

To couple the connecting rod with the oscillating lever, a bearing pin extending in the direction of the longitudinal axis of the two-armed oscillating lever is provided on the lever arm cooperating with the connecting rod.

In all embodiments, the connecting rod has its one end coupled with the two-armed lever through the bearing bore in a manner allowing it to pivot about the bearing pin of the associated lever arm, while its other end is coupled with the eccentric through a head formed at the shank end of the connecting rod.

It is a further advantage of the present invention that it allows embodiments relating particularly to the adaptation of this device to predetermined mounting criteria in appliances of the type referred to, without necessitating additional expenditure in terms of construction. To this end, the longitudinal axis of the lever arm of the two-armed oscillating lever cooperating with the connecting rod may extend either in the direction of the longitudinal axis of the lever arm provided with a pin or, alternatively, it may extend at an angle to this longitudinal axis, with the two-armed configuration being maintained.

In this embodiment, it has to be made sure that the longitudinal axis of the connecting rod intersects the longitudinal axis of the associated lever arm of the two-armed oscillating lever at right angles. Moreover, it will be understood that the conversion of motion as disclosed in this invention is not intended to be limited to a specific lever ratio of the two arms of the two-armed lever. This ratio may be varied in accordance with the individual application.

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Further features, advantages and details of the invention will become apparent from the subsequent description and the drawings showing preferred embodiments of devices for the conversion of motion intended, for example, for use in a dry shaving apparatus. In the drawings,

FIG. 1 is a schematic representation of a two-armed oscillating lever and a connecting rod showing their respective axes of motion;

FIG. 2 is a perspective view of a two-armed oscillating lever with a rigid connecting rod coupled therewith;

FIG. 3 is a view of a joint coupling of FIG. 2, showing the connecting rod in longitudinal section;

FIG. 4 is a perspective view of a two-armed oscillating lever and a fork-shaped connecting rod provided with film hinges;

FIG. 5 is a view of a two-armed oscillating lever and a fork-shaped connecting rod showing the fastening means in section; and

FIG. 6 is a schematic representation of structural variations of the two-armed oscillating lever.

Referring now to FIG. 1, reference numeral 1 identifies the two-armed oscillating lever 1, reference numeral 2 designates the lever arm to be provided with a pin for the tool to be driven which is, for example, the cutter assembly of a dry shaver, and reference numeral 3 denotes the lever arm cooperating with the connecting rod 4.

The two-armed oscillating lever includes a bearing bore 5 having a pivot axis y. A pin, not shown, which is provided on a housing of the small appliance engages into the bearing bore. The pivot point of the longitudinal axis x extending through the lever arms 2 and 3 lies in the pivot axis y.

At bottom dead center of the radial swivelling movement RS of the two-armed oscillating lever 1 about the pivot axis y, the longitudinal axis z of the connecting rod 4 intersects the longitudinal axis x at right angles. The pivot center 7 lies in the point of intersection of the two longitudinal axes x and z.

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The connecting rod 4 is provided with a head 6 having a bore 14 with a center axis K which is engaged by an eccentric pin, not shown, for driving purposes. The circular movement of the center axis K of the head 6 is translated through the head 6 and the connecting rod 7 carried in the pivot center 7 into an angular component WK and a linear component LK. The linear component LK results in a radial swivelling movement RS of the two-armed oscillating lever 1 with its longitudinal axis x, comprising a linear component LK and a linear height component HK.

In accordance with the invention, the components of motion identified in the foregoing and generally referred to as axes of motion in the following are directed to a pivot center 7 lying in the longitudinal axis x of the two-armed oscillating lever and are controlled by means of a single joint coupling uniting in itself all degrees of freedom.

FIG. 2 shows a joint coupling uniting in itself all degrees of freedom between the two-armed oscillating lever 1 and the connecting rod 4, with all axes of motion converging directly in the pivot center.

A pin 8 for coupling with a tool is provided on the lever arm 2 of the two-armed oscillating lever 1 comprised of lever arms 2 and 3 and the bearing bore 3, while a stepped bearing pin 9 is provided on the lever arm 3. The longitudinal axis x of the two-armed oscillating lever 1 extends through both the pin 8 and the bearing pin 9. The step provided on the bearing pin subdivides the bearing pin into a larger-diameter portion 9.1 and a reduced-diameter portion 9.2, with the transition between the two bearing pin portions being referred to as a stop means 10. The rigid connecting rod 4 abuts against the stop means 10 which is of rounded configuration. In this embodiment, the bearing pin portion 9.2 extends through a bearing bore 11 (FIG. 3) provided in the connecting rod 4. The portions 9.1 and 9.2 of the bearing pin 9 may be directly formed on the lever arm 3. Alternatively, the bearing pin portion 9.2 may also be a metal pin inserted into the bearing pin portion 9.1.

At its end remote from the bearing bore 11, the connecting rod 4 has a head 6 with a bore 14 for receiving an eccentric pin.

Details of the joint coupling of FIG. 2 are illustrated in FIG. 3 showing a partial section through the connecting rod 4. The wall thickness of the connec-

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ting rod 4 is significantly reduced in the area of the joint coupling. This is accomplished, for example, by two opposed dish-shaped recesses 12, 13 having the longitudinal axis x of the two-armed oscillating lever extending through their lowermost points. The center axis of the bearing bore 11 lies in the longitudinal axis x . As the lever arm 3 executes a swivelling movement with its longitudinal axis x and the connecting rod 4 pivots over a partial area about the pivot axis x , the spherically rounded stop means 10 rolls along the walls inside the dish-shaped recess 13. The dish-shaped recess 13 is configured such as to permit an unhindered rolling motion or an unhindered movement of these joint members. This applies equally to the clearance between the wall of the bearing bore 11 and the bearing pin portion 9.2 which has to be sufficiently large to allow an unhindered swivelling movement of the bearing pin portion 9.2 with the longitudinal axis x within the bearing bore 11 for each predetermined wall thickness of the connecting rod 4 in the area of the bearing bore 11.

FIG. 4 shows a two-armed oscillating lever 1 which is adapted to pivot about the bearing bore 5 and has its longitudinal axis x extend centrically through the pin 8, the bearing bore 5 and the bearing pin 9.

The connecting rod 4 is of fork-shaped configuration. The prongs 17 and 18 converge at one end in a shank 19 having the head 6 formed on the shank end, and are interconnected by a cross piece 20 at the other end. An arm 21 extending into the opening between the prongs is formed on the cross piece 20. The prongs 17 and 18 are each provided with a film hinge 22, 23 whose common center/bending axis BM intersects the longitudinal axis x . The film hinges 22, 23 are configured such that the flexible prongs ensure an S-shaped bending curve during the radial swivelling movement RS of the lever arm 3 to compensate for the height component HK of the lever arm 3.

At its one end, the connecting rod 4 is connected with the eccentric pin 15 of the eccentric 16 through the bore 14 in the connecting rod head 6, while its other end is pivotally mounted on the bearing pin 9 by the angular component WK through a bearing bore provided in the arm.

Further details of the joint coupling between the connecting rod 4 and the lever arm 3 are illustrated in FIG. 5. The bearing pin 9 provided on the lever arm 3 is comprised of the two bearing pin portions 9.1 and 9.2.

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The stop means 10 formed in the area of transition between the two bearing pin portions as a result of their different diameters is of the same planar configuration as the area of the arm 21 formed on the cross piece 20 of the connecting rod 4, which area surrounds the bearing bore 11. In assembled condition, the bearing bore 11 surrounds the bearing pin portion 9.2 with little clearance, with the arm 21 resting against the stop means 10. The pivot center of this joint coupling lies inside the bearing bore 11 in the longitudinal axis x extending through the bearing bore 11. In this pivot center, all axes of motion of the two-armed oscillating lever 1 and of the connecting rod 4 converge directly and indirectly.

The fastening means in the form of two hook members 24 and 25 formed on the arm 21 and engaging into a peripheral groove 26 provided on the bearing pin portion 9.1 serve to facilitate the assembly of the two-armed oscillating lever 1 and the connecting rod 4. To introduce the hook members 24 and 25 into the groove 26, the bearing pin portion 9.1 includes two grooves 27 extending parallel to the longitudinal axis x , one groove thereof being shown in FIG. 5. The hook members 24 and 25 are configured such that at no place do they touch the bearing pin portion 9.1 when the arm 21 is in abutment with the stop means 10.

The joint coupling between the connecting rod 4 and the two-armed oscillating lever 1 as disclosed in the invention permits a plurality of structural variations of the two-armed oscillating lever 1. Some of these are shown schematically in FIG. 6 in which the lines drawn in full illustrate the basic version described with reference to the preceding Figures, while two variations are illustrated by dashed lines by way of for example.

The basic version includes the two-armed oscillating lever 1 with the two lever arms 2 and 3, the pin 8, the bearing pin 9 with its portions 9.1. and 9.2, the connecting rod 4, the eccentric pin 15, the eccentric 16 and the rotating motor 28. The length A of the lever arm 2 extends from the center of the bearing bore 5 up to the point of coupling 29 with a tool, not shown, engaged with the pin, while the length B of the lever arm 3 extends from the center of the bearing bore 5 up to the pivot center 7. The coupling point 29, the center of the bearing bore 5 and the pivot center lie in the longitudinal axis x of the two-armed oscillating lever. The lever ratio $A:B$ of the lever arms 2 and 3 may be $A = B$ or, alternatively, it may differ, i.e., $A > B$ or $A < B$, depending on the individual application.

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Further, it is possible to angle the lever arm 3 co-operating with the connecting rod 4. If this embodiment is chosen, it only has to be ensured that the longitudinal axis of the angled lever arm 3 which is referred to by x_1 in FIG. 6 intersects the longitudinal axis x either in the center of the bearing bore 5 or in the lever arm 3, and that the longitudinal axis z of the connecting rod 4 intersects the longitudinal axis x_1 of the angled lever arm 30 at right angles.



Patent Claims

1. A device for converting the rotary motion of an eccentric (16) driven by a motor shaft into a reciprocating motion of a tool, coupled with a pin (8), of electrically powered small appliances having pivotally mounted in their housings a two-armed oscillating lever (1) provided with the pin (8) and a connecting rod (4) connecting the two-armed oscillating lever with the eccentric, with the connecting rod (4) being coupled with the eccentric (16) by means of a pivot bearing (14, 16), characterized in that the two-armed oscillating lever (1) and the connecting rod (4) are coupled with each other through a joint coupling allowing all rotations and a translation, parallel to the longitudinal axis (x), of the connecting rod (4) relative to the oscillating lever (1), and that the pivot center (7) lies in the longitudinal axis (x) of the associated lever arm (3, 30) of the two-armed oscillating lever (1).

2. A device as claimed in claim 1, characterized in that the pivot center (7) coincides with the point of intersection of the longitudinal axes (x, x₁, z) of the associated lever arm (3, 30) of the two-armed oscillating lever (1) and the connecting rod (4).

3. A device as claimed in claim 1, characterized in that a bearing pin (9) extending in the direction of the longitudinal axis (x) of the two-armed oscillating lever (1) is provided on the lever arm (3, 30) cooperating with the connecting rod (4), that the rigid connecting rod (4) has at its one end a bearing bore (11) of relatively thin wall thickness surrounding the bearing pin (9, 9.2) with a predetermined clearance therebetween, that the bearing pin (9) is provided with a stop means (10) against which the connecting rod (4) abuts, and that both the stop means (10) and the area around the bearing bore (11) are formed such as to ensure an unhindered rolling action in the contact area in all directions of motion of connecting rod (4) and two-armed oscillating lever (1).

4. A device as claimed in claim 3, characterized in that the stop means (10) on the bearing pin (9) is of rounded configuration.

5. A device as claimed in claim 3 and claim 4, characterized in that the connecting rod (4) is of rounded configuration in the area of the bearing bore (11), said rounding being conformed to the rounded contours of the stop means (10).

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6. A device as claimed in claim 1 or claim 2, characterized in that the connecting rod (4) is pivotally mounted on the associated lever arm (3, 30) of the two-armed oscillating lever (1) about the longitudinal axis (x) thereof, and that the connecting rod (4) includes a pair of joints/film hinges (22, 23) whose center/bending axis (BM) intersects the longitudinal axis (x) of the associated lever arm (3, 30) of the two-armed oscillating lever (1).

7. A device as claimed in any one of the claims 1, 2 or 5, characterized in that the connecting rod (4) has a fork-shaped end, that the prongs (17, 18) of the connecting rod (4) are interconnected by a cross piece (20), that said cross piece (20) is provided with an arm (21) which extends into the opening between the prongs and includes a bearing bore (11), and that the prongs (17, 18) of the fork are each provided with a film hinge whose common center/bending axis (BM) intersects the center axis of the bearing bore (11).

8. A device as claimed in claim 6, characterized in that a bearing pin (9) extending in the direction of the longitudinal axis (x) of the two-armed oscillating lever (1) is provided on the lever arm (3, 30) cooperating with the connecting rod (4).

9. A device as claimed in any one of the claims 6 to 8, characterized in that the connecting rod (4) has its one end coupled with the two-armed oscillating lever (1) through the bearing bore (11) in a manner allowing it to pivot about the bearing pin (9) of the associated lever arm (3, 30), while its other end is coupled with the eccentric (16) through a head (6) formed at the end of the shank (19) of the connecting rod (4).

10. A device as claimed in any one of the claims 6 to 9, characterized in that a bearing pin (9) having a peripheral groove (26) is provided on the arm (3, 30) of the two-armed oscillating lever (1) cooperating with the connecting rod (4), said groove being accessible through two opposed grooves (27) extending in the direction of the bearing pin portion (9.1).

11. A device as claimed in claim 7, characterized in that hook-shaped fastening means (24, 25) are formed on the arm (21).



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12. A device as claimed in one or several of the preceding claims, characterized in that the longitudinal axis (x, x1) of the lever arm (3, 30) of the two-armed oscillating lever (1) cooperating with the connecting rod (4) extends in the direction of the longitudinal axis (x) of the lever arm (2) provided with a pin (8) or, alternatively, extends at an angle to said longitudinal axis (x).

13. A device as claimed in one or several of the preceding claims, characterized in that the longitudinal axis (z) of the connecting rod (4) intersects the longitudinal axis (x, x1) of the associated lever arm (3, 30) of the two-armed oscillating lever (1) at right angles.

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List of References

- 1 Two-armed Oscillating Lever
- 2 Lever Arm
- 3 Lever Arm
- 4 Connecting Rod
- 5 Bearing Bore
- 6 Connecting Rod Head
- 7 Pivot Center
- 8 Pin
- 9 Bearing Pin
- 9.1 Bearing Pin Portion
- 9.2 Bearing Pin Portion
- 10 Stop Means
- 11 Bearing Bore
- 12 Dish-shaped Recess
- 13 Dish-shaped Recess
- 14 Bore
- 15 Eccentric Pin
- 16 Eccentric
- 17 Prong
- 18 Prong
- 19 Shank
- 20 Cross Piece
- 21 Arm
- 22 Film Hinge
- 23 Film Hinge
- 24 Hook Member
- 25 Hook Member
- 26 Groove
- 27 Grooves
- 28 Rotating Motor
- 29 Coupling Point
- 30 Angled Lever Arm

- K Center Axis of Bore
- RS Radial Swivelling Movement
- WK Angular Component
- LK Linear Component
- HK Height Component
- Y Pivot Axis
- x Longitudinal Axis of Lever Arm 2 and/or 3
- x1 Longitudinal Axis of Angled Lever Arm 30
- Z Longitudinal Axis of Connecting Rod 4
- BM Center Bending Axis