Medical hand-held device

Description

The invention concerns a medical hand-held device, in particular blood glucose meter comprising a housing with a cassette compartment, an exchangeable test tape cassette received in the cassette compartment and a drive assembly comprising an electric motor and a gear arrangement adapted for rotating a tape spool of the test tape cassette, such that a test tape of the test tape cassette can be wound forwards and test elements thereon can be provided for successive use.

Such devices are used in practice as blood glucose meters for the self-diagnosis of diabetics. A plurality of test fields is provided on a spoolable test tape in the tape cassette. The reactive test fields are examined photometrically after the application of a small amount of blood sample in order to determine the glucose content as exactly and reliably as possible. Such tape cassettes are intended to be inserted as a disposable part into a compact hand-held device housing in order to allow the necessary analytical steps to be carried out automatically and rapidly. In addition to a reliable positioning of the test elements, it is also necessary for practical purposes to ensure that their on the spot use is not impaired by excessive noise development. In this context, the document WO 2010/046323 A1 proposes using a compact high-speed motor in combination with a reduction gear unit.

On this basis the object of the invention is to further improve the known test devices and to achieve a reliable test element positioning with little interfering noise in a compact construction.

The combination of features stated in claim 1 is proposed to achieve this object. Advantageous embodiments and further developments of the invention are derived from the dependent claims.

According to a first aspect of the invention, a hand-held medical device is described, the hand-held medical device comprising a housing with a cassette compartment, an exchangeable test tape cassette received in the cassette compartment, and a drive assembly comprising an electric motor and a gear arrangement adapted for rotating a tape spool of the test tape cassette, wherein a test tape of the test tape cassette can be wound forwards and test elements thereon can be provided for successive use, wherein the gear arrangement has a worm drive in which a worm meshes with a worm wheel and a multistage speed-reducing unit comprising plurality of spur gears arranged between the worm wheel and an output gear directly coupled to the tape spool, wherein each of the plurality of spur gears has at least about 10 teeth, and wherein the worm is directly mounted on a motor shaft of the electric motor.

According to a second aspect of the invention, another hand-held medical device is described, the hand-held medical device comprising a housing with a cassette compartment; an exchangeable test tape cassette received in the cassette compartment, the test tape cassette comprising a test tape having test elements thereupon that can be provided for successive use and at least one tape spool connected to the test tape; and a drive assembly comprising an electric motor and a gear arrangement adapted for rotating the tape spool, wherein the gear arrangement has a worm drive in which a worm meshes with a worm wheel and a multistage speed-reducing unit comprising a plurality of spur gears arranged between the worm wheel and an output gear directly coupled to the tape spool, wherein the plurality of spur gears are arranged in a non-linear configuration so that centers of the spur gears span a polygon selected from the group consisting of a triangle and a quadrangle, and wherein a rotational axis of the electric motor is skewed or perpendicular to rotational axes of the plurality of spur gears.

The invention is based on the idea of using a worm drive and subsequent spur gears in order to reduce size and to control the rotational movement precisely. Accordingly it is proposed according to the invention that the gear arrangement has a worm drive in which a worm meshes with a worm wheel and a multistage speed-reducing unit downstream the worm drive and comprising several spur gears arranged between the worm wheel and an output gear that can be directly coupled to the tape spool.

Preferably, the worm is directly mounted on the motor shaft. This combination allows to considerably reducing size and operational noise while at the same time ensuring a sufficient turning moment for the rotation of the tape spool. Specifically, a high gear ratio can be performed in a small construction space, and the transmission can be kept non-reversible and with low backlash.

In a preferred embodiment the speed-reducing unit has at least two, preferably three meshing gear pairs for reducing the rotational speed between the worm drive and the output gear.

Another particularly advantageous embodiment provides that the speed reduction ratio between the rotational speed of the electric motor and the output gear is more than 300, preferably more than 400 and most preferably in the range between 400 and 500. Such a gear ratio has surprisingly been found to provide an optimum for several boundary conditions which are critical for the device design. Particularly, size reduction and elimination of noise as well as sufficient output torque in combination with a small-power DC motor are important for such a hand-held medical device.

In order to further avoid operational noise, it is advantageous when wherein each of the spur gears has at least 10, preferably at least 14 teeth.

It is also advantageous when the output gear can provide a torque on the tape spool of more than 20 mNm and preferably about 50mNm. This allows reliable tape transport even through shielding seals while at the same time avoiding an unwanted straining of the tape.

Another advantageous embodiment provides that the tape cassette comprises a first tape spool for unused tape, a second tape spool for used tape and a seal through which the test tape is transported between the spools, where the output gear is acting on the second spool. In this way, a large number of tests can be stored on the tape, without the user having to handle waste material.

A further improvement in safe and reliable handling can be achieved when the worm drive is self-locking such that the worm gear cannot drive the worm when a reverse torque is exerted on the tape spool. In this context, it should be guaranteed that the self-locking force of the worm drive is greater than 10 mNm and preferably greater than 14 mNm.

In order to achieve a compact configuration, it is advantageous when the rotational axes of the spur gears are parallel to the rotational axis of the tape spool. A further improvement in this direction is due to the fact that the rotational axis of the electric motor is skewed or perpendicular to the rotational axes of the spur gears.

For a further reduction of the total constructional dimensions it is also advantageous when the spur gears comprise overlapping pairs of stepped wheels, and when the spur gears are arranged in a non-linear configuration, such that the centres of the spur gears span a polygon and in particular a triangle or quadrangle.

A further manufacturing simplification and constructional improvement can be achieved when the drive assembly is mounted between a top-cover and a

bottom-cover of a gearbox. It is also beneficial when the axes of the spur gears extend from the bottom-cover to the top-cover of the gearbox and the shaft of the electric motor lies horizontally between the covers.

For further improvement of the assembly it is advantageous when the top-cover and bottom-cover of the gearbox are detachably connected together preferably by means of screws.

The invention is further elucidated in the following on the basis of an embodiment example shown schematically in the drawings, where

Fig. 1 is a top view of a cassette-type blood glucose meter illustrated with the cover removed and showing the location of a cassette drive assembly;

Fig. 2 is an expanded perspective view of the cassette drive assembly;

Fig. 3 is an exploded view of the cassette drive assembly;

Fig. 4 is a top view of the cassette drive assembly with the covers removed and illustrating a worm drive in combination with a speed-reducing spur gear unit.

The drawings show a medical device configured as a portable blood glucose meter 10 for self-monitoring of blood glucose and comprising a housing 12 with a cassette compartment 14, , a disposable tape cassette 16 loaded replaceable in the cassette compartment and a drive assembly 18 for rotating a tape spool 20 of the tape cassette 16, such that an analytical test tape 22 of the cassette can be wound forwards and reactive test fields thereon can be provided at an application tip 24 for application and investigation of a blood sample. The on-board photometric detection of the analyte is known per se in the state of the art and needs not to be explained in further detail.

Fig. 1 shows the glucose meter 10 from the broad side with a housing cover removed. A housing opening for sample application is shown closed by a moveable protective cover 26. The tape spool 20 is intended for winding-on the used section of the test tape 22, whereas a tape spool 28 for unused tape is shielded in a chamber closed by a seal 30 which allows the tape to be pulled there through. The drive assembly 18 is adapted to ensure a reliable tape transport through the seal 30, while extensively reducing the necessary installation space and the operating noise. For such purposes, the drive assembly 18 comprises a high-speed DC micro motor 32 that can be energized via a control logic on a circuit board 34 in connection with a power supply such as batteries 36.

Fig. 2 illustrates the drive assembly 18 comprising a gearbox 38, the DC motor 32 and a subsequent gear arrangement 40 adapted for reducing the rotational speed and correspondingly increasing the torque in order to guarantee an adequate rotation of the tape spool 20. The gearbox 38 consists of a bottom cover 42 and a top-cover 44 secured to the bottom cover via screws 46. The bottom cover 42 forms a chamber 48 for locating the DC motor 32 in an orientation where the motor shaft 50 lies horizontally between the covers 42, 44. So, the total height reduces and the assembly becomes compact.

As the exploded view of Fig. 3 further elucidates, the gear arrangement 40 comprises a worm drive 52 and a multistage speed-reducing transmission unit 54.

The worm drive 52 possesses a worm 56 in the form of a cylindrical screw and a worm wheel 58. In the assembled state, the worm 56 is mounted on the motor shaft 50 such that it meshes with the worm wheel 58 at 90°. The axis of the helical worm 56 and respectively the motor shaft 50 is neither parallel nor intersecting with the axis of the worm wheel 58.

The transmission unit 54 comprises several spur gears 60,62,64,66 in the drive train following the worm wheel 58 and forming three meshing gear pairs for a reduced gear ratio. The spur gears 62, 64 comprise stepped wheels with a large and a small diameter toothed wheel 62',62'' and 64',64'' in a coaxial configuration. For supporting the gears 60,62,64,66, the bottom cover 42 has four upstanding axle journals 68 which are parallel to each other and engage in holes 70 of the top cover

Fig. 4 shows the complete drive assembly in the mounted state comprising the DC motor 32, the worm drive 52, the transmission unit 54 and an output gear 72 which supports the tape spool 20 and can be directly coupled thereto by a central drive journal.

The worm 56 and the worm wheel 58 have rotational axes at 90° to each other. For each full turn of the worm 56, the circumferentially toothed worm wheel 58 advances only one tooth. Given a 22 tooth worm wheel 58, the worm drive 52 will reduce the DC motor speed by the ratio of 22:1. This can be achieved in a considerably smaller volume as compared to plain spur gears. At the same time, the angular position of the gear 60 integral with the worm wheel and ultimately the tape position can be precisely controlled. Moreover, the worm drive 52 has the property that the worm 56 can easily turn the worm wheel 58, but the wheel cannot turn the worm, due to shallow angle of the worm spiral and the greater friction involved. Thus, the direction of transmission is not reversible and the worm drive 52 is self-locking. When the self-locking force exceeds 10 mNm (Milli-Nm) and preferably 14 mNm, it is guaranteed for practical purposes that the test tape 22 will be unmovable in the idle mode.

In the transmission unit 54 following the worm drive 52, all spur gears have at least 14 teeth in order to ensure a low-noise operation. The rotational axes 68 of the spur gears are parallel to each other and to the axes 74 of the

output gear 72 and the tape spool 20, respectively. In order to achieve a high gear ratio in a limited space, the transmission unit 54 comprises overlapping pairs of stepped wheels 60, 62, 64. In addition, to reduce the total longitudinal length, the axes 68 of the spur gears 60 – 66 are arranged in a non-linear configuration, such that the centres of the spur gears span a trapezoid quadrangle in the shown arrangement.

For a preferred embodiment, the gear parameters of the gear arrangement 40 are given in the following table I, where n is the number of teeth, m is the module and PD, OD, ID are the pitch diameter, outer diameter and inner diameter (in millimeters), and CC the center to center distance of the spur gears identified by their reference numbers in the first line:

Table I

	56	58	60	62'	62''	64'	64''	66	72
n	1	22	14	35	14	26	14	22	60
m	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4
PD	3.2	8.8	4.2	10.5	5.6	10.4	5.6	8.8	24
OD	4	9.6	4.8	11.1	6.4	11.2	6.4	9.6	24.8
ID	2.2	7.8	3.45	9.75	4.6	9.4	4.6	7.8	23
CC	6		7.35		8		7.2		

As can be taken from table I, the total gear ratio is 438, thus reducing the DC motor speed in the range of a few thousand rotations per second to an output speed of the output gear of less than 10/s. Due to this high gear ratio, a relatively week, quiet and compact micro motor 32 can be employed while an output torque at the output gear 72 of more than 20 mNm still can be achieved.

Claims

1. A hand-held medical device comprising:
a housing with a cassette compartment, an exchangeable test tape cassette received in the cassette compartment, and a drive assembly comprising an electric motor and a gear arrangement adapted for rotating a tape spool of the test tape cassette, wherein a test tape of the test tape cassette can be wound forwards and test elements thereon can be provided for successive use, wherein the gear arrangement has a worm drive in which a worm meshes with a worm wheel and a multistage speed-reducing unit comprising plurality of spur gears arranged between the worm wheel and an output gear directly coupled to the tape spool, wherein each of the plurality of spur gears has at least about 10 teeth, and wherein the worm is directly mounted on a motor shaft of the electric motor.

2. A medical device according to claim 1, wherein the multistage speed-reducing unit has at least two meshing gear pairs for reducing the rotational speed between the worm drive and the output gear.

3. A medical device according to any one of the preceding claims, wherein of the output gear has about 60 teeth, and wherein the electric motor and the output gear have a speed reduction of at least about 300.

4. A medical device according to claim 1, wherein the output gear has about 60 teeth, and wherein of the electric motor and the output gear have a speed reduction ratio of at least about 400.

5. A medical device according to claim 3, wherein the output gear can provide a torque on the tape spool of at least about 20 mNm.

6. A medical device according to claim 1, wherein the test tape cassette further comprises a first tape spool for unused tape, a second tape spool for used tape, and a seal through which the test tape is transported between the first spool and the second spool, and where the output gear is acting on the second spool.

7. A medical device according to claim 1, wherein the worm drive is self-locking such that the worm wheel cannot drive the worm when a torque is exerted on the tape spool.

8. A medical device according to claim 7, wherein the torque exerted on the tape spool is at least about 10 mNm.

9. A medical device according to claim 7, wherein the torque exerted on the tape spool is at least about 14mNm.

10. A medical device according to claim 1, wherein rotational axes of the plurality of spur gears are parallel to a rotational axis of the tape spool.

11. A medical device according to claim 1, wherein a rotational axis of the electric motor is skewed or perpendicular to rotational axes of the plurality of spur gears.

12. A medical device according to claim 1, wherein the plurality of spur gears comprise overlapping pairs of stepped wheels.

13. A medical device according to claim 1, wherein the plurality of spur gears are arranged in a non-linear configuration, such that the centers of the spur gears span a polygon selected from the group consisting of a triangle or quadrangle.

14. A medical device according to claim 1, wherein the drive assembly is mounted between a top-cove and a bottom-cover of a gearbox.

15. A medical device according to claim 14, wherein axes of the plurality of spur gears extend from the bottom-cover to the top-cover of the gearbox, and wherein the shaft of the electric motor lies horizontally between the covers.

16. A medical device according to claim 14, wherein the top-cover and the bottom-cover of the gearbox are detachably connected.

17. A medical device according to claim 14, wherein the top-cover and bottom-cover are detachably connected by screws.

18. A medical device according to claim 1, wherein the worm wheel has 22 teeth and reduces motor speed by a ratio of 22:1.

19. A medical device according to claim 2, wherein the multistage speed-reducing unit has three meshing gear pairs.

20. A hand-held medical device comprising:
a housing with a cassette compartment; an exchangeable test tape cassette received in the cassette compartment, the test tape cassette comprising a test tape having test elements thereupon that can be provided for successive use and at least one tape spool connected to the test tape; and a drive assembly comprising an electric motor and a gear arrangement adapted for rotating the tape spool, wherein the gear arrangement has a worm drive in which a worm meshes with a worm wheel and a multistage speed-reducing unit comprising a plurality of spur gears arranged between the worm wheel and an output gear directly coupled to the tape spool, wherein the plurality of spur gears are arranged in a non-linear configuration so that centers of the spur gears span a polygon selected from the group consisting of a triangle and a quadrangle, and

wherein a rotational axis of the electric motor is skewed or perpendicular to rotational axes of the plurality of spur gears.

21. A medical device according to claim 20, wherein each of the plurality of spur gears has at least about 10 teeth, wherein the output gear has about 60 teeth, and wherein the worm is directly mounted on a motor shaft of the electric motor.

22. A medical device according to claim 20, wherein the worm wheel has 22 teeth and reduces motor speed by a ratio of 22:1.

23. A medical device according to claim 20, wherein the multistage speed-reducing unit has three meshing gear pairs.