Pedometer

Project Report

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INTRODUCTION

Pedometer is a device, which is worn by a person on his belt and it measures the number of steps and the distance walked by the person. It is generally used by people who do measured exercise every day. The device counts the number of steps taken by the person and multiplies it by the average step length fed to give the distance walked by the person. In the present project, we are measuring the number of steps the person takes. This has to be appropriately multiplied by the stride length of the person to calculate the actual distance traveled by the person.

PROBLEM DEFINITION

The design problem is to design and fabricate a small mechanical Pedometer which can at least measure two kilometers on a dial or counter. The size of the pedometer is to be about 50×50×25 mm.

Assuming the average stride of a person is 0.33 m, the pedometer must measure about 6000 steps approximately.

This can be achieved by using a 3 digit counter which can measure till 999 and a gear reduction of 1:10. Thus the pedometer will be able to measure 9990 steps which is more than the required specification. A more detailed calculation of the measuring system will be given later.

Step Counting Mechanism

The basic principle behind the counting mechanism is that when a person moves, he bends a little, so his center of gravity goes down. For every step first the center of gravity goes down and then up, this to and fro motion continues throughout walking.

Mechanical Systems

Commercially available pedometers use many different mechanisms to measure the number of steps taken by the person while walking. For example, the ball mechanism, in which a ball is put in a vertical tube, which oscillates up and down on each step and hence counting is done.

Another mechanism is the spring and magnet mechanism, where the spring dips on each step, registering the step through the reed switch and then spring pulls it back to the original position. A reed switch is a switch which closes or opens the circuit based on whether the magnet is close to it or not. There are two types of reed switches.

- **Normally closed type** in which the circuit is normally closed but is opened as the magnet is brought near.
- **Normally open type** in which the circuit is normally open but is closed as the magnet is brought near.

Both these types can be used in a pedometer but the counting circuit has to be modified accordingly.

PENDULUM MECHANISM

In this mechanism a pendulum oscillates as the person walks. These oscillations are counted by a counter and are used to find the number of steps taken by the person. The pendulum is connected to a ratchet and pawl mechanism which prevents movement of the counter in the opposite direction. This is the mechanism used in this project.

ELECTRONIC SYSTEMS

In this method a mercury switch is used to count the number of steps. Mercury switch has a small tube containing mercury (half-filled), and two wires soldered to it, which dip into the mercury. In the horizontal position, both the leads are dipped in mercury and hence the wires are short. But, on tilting the tube, the mercury slides sideway and the connection between the two wires break. The tilting motion while walking is used to note logic zero and one. An instance of wires going open tells us that a step has been taken. This can be electronically counted.

Electronic systems depend on the change in input from zero to one to count the number of steps. The number of steps is automatically counted and multiplied by the average step length of the person. The person can input his step length into the device and the output is usually read on a digital LCD display. Almost all modern pedometers are electronic as they are more rugged and easy to use.

PARTS DESCRIPTION

This section gives a detailed description of the parts which are used in the pedometer. The main parts of the pedometer are the

- Counting Mechanism
- Ratchet Wheel
- Free Wheel

COUNTING MECHANISM

The counting mechanism consists of a worm and worm wheel arrangement to reduce the number of rotations of the number wheel. The worm wheel is connected to the first number wheel directly. Hence for one rotation of the worm wheel the first number wheel rotates by one complete rotation.

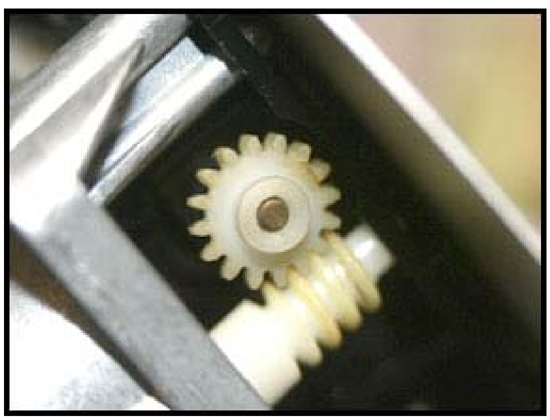

Figure 1 The worm and worm wheel

There is an auxiliary shaft on top of the main numbers shaft. The auxiliary shaft has helper gears in between the number wheels. The numbers wheel has pegs correctly positioned on them which engage with the helper gears.

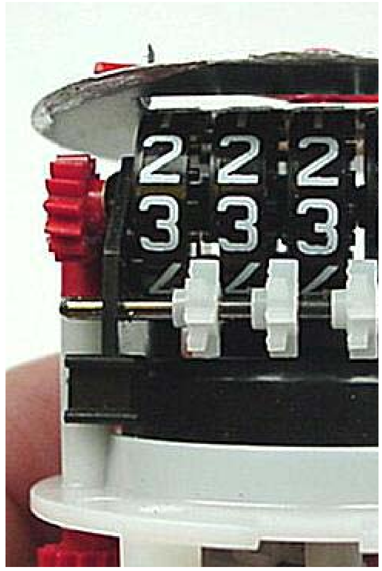

Figure 2 The helper gears on the auxiliary shaft

Each indicator has a row of pegs sticking out of one side, and a single set of two pegs on the other side. When the set of two pegs comes around to the white helper gears, one of the teeth falls in between the pegs and turns with the indicator until the pegs pass. This gear also engages one of the pegs on the next bigger indicator, turning it a $1/10^{th}$ of a revolution.

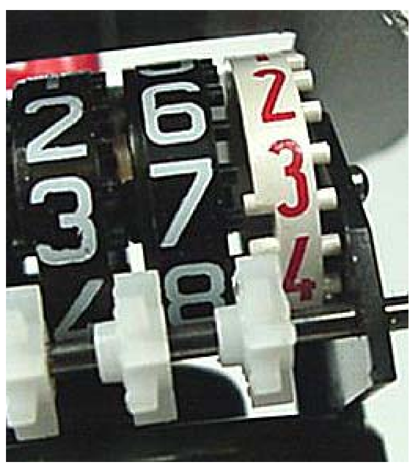

Figure 3 Helper wheel engage with pegs

In Figure 3, there are two pegs on the white wheel between the number "3" and "4". One of the gear teeth on the white gear falls in between these two pegs, one time per revolution, causing the black gear next to it to move one-tenth of a revolution.

Thus the wheel is able to count 999 revolutions of the worm wheel. The total number of revolutions counted is further multiplied by the gear ratio of the worm and worm wheel.

RATCHET WHEEL

The ratchet wheel is used to allow rotation of the input wheel to the counter in only one direction.

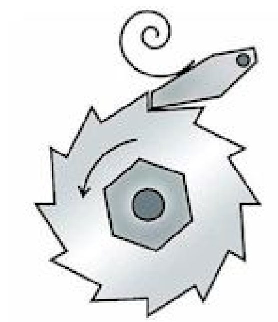

Figure 4 Ratchet and Pawl

In a mechanical ratchet shown in Figure 4, the pawl follows the contour of the toothed wheel. The teeth themselves are gently sloped on one side, and the pawl is mounted so that it slides smoothly over them when the wheel turns in one direction. On the other side of the teeth, however, the points fall away sharply, so that when a force tries to spin the wheel in the opposite direction, the pawl jams against a tooth, preventing the wheel from turning. The spring above the Pawl keeps it in contact with the ratchet at all times.

Thus even when the ratchet is subject to forces that would move the wheel back and forth, the action of the pawl and the teeth allows the wheel to move in only one direction.

FREE WHEEL

The ratchet and pawl mechanism cannot be used directly in the pedometer. Instead a special mechanism called freewheel is used. The freewheel is used in the rear wheel of bicycle which helps the cycle to coast without any pedaling action. Like the ratchet and pawl mechanism the freewheel also allows rotation in only one direction.

There are different kinds of construction of freewheels. The **Sprag Freewheel** has outer and inner rings with cylindrical races. Arranged in between are the individually sprung sprags. Due to varying sprag shapes several types of freewheeling actions are possible.

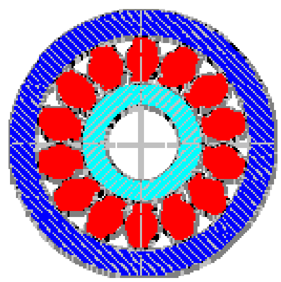

Figure 5 Sprag Freewheel

The Roller Ramp Freewheel is equipped with roller ramps on either the inner or the outer ring and a cylindrical race on the corresponding other ring. The individually sprung rollers are arranged in between. This is the most common type of freewheel.

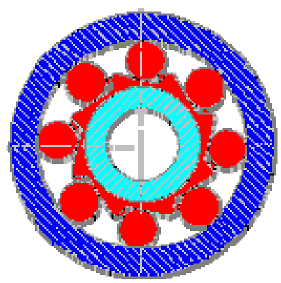

Figure 6 Roller Ramp Freewheel

WORKING

The Pedometer is assembled as shown in the assembly drawing. The input shaft to the counter is connected to the freewheel which in turn is connected to the pendulum.

As the person walks the pendulum oscillates once for every stride the person takes. When the pendulum moves forward, the freewheel gets engaged with the input shaft of the counter and rotates the input shaft of the counter. The counter rotates by a fraction of a rotation. As the pendulum swings in the reverse direction, the freewheel is free to rotate and the motion of the pendulum is not transmitted to the input shaft. Thus the input shaft rotates only in one direction and counts the number of steps.

The oscillations of the pendulum are restricted to a small angle. This angle is calculated after taking into account the number of ratchet pegs in the freewheel.

SPECIFICATIONS

The dimensions of the pedometer are approximately

Length = 30 mm.
Breadth = 30 mm.
Height = 60 mm.

The calculation of number of steps taken by a person will depend on the gear ratio as well as the number of ratchets in the freewheel.

Number of ratchets in the freewheel = 42
Number indicated in the counter for 100 rotations of the input shaft = 64
Angle of oscillations of the pendulum

$$\frac{1}{42} \times 360^{\circ} = 8.5714^{\circ}$$

Length of the pendulum = 30 mm

Clearance at tip of the pendulum

$$2 \times 30 \times \sin(8.5714) = 8.94 \text{ mm}$$

The clearance can be approximately taken as 9 mm i.e. 4.5 mm on each side of the mean position.

Number indicated on the counter for 1 step is calculated as

$$\frac{1}{42} \times \frac{64}{100} = 0.01524$$

Minimum steps that can be measured = 66 steps

Maximum steps that can be measured = 65560 steps

Assuming the average stride length of a person is 0.33m the specifications of the pedometer are

Minimum distance	=	**22 m**
Maximum distance	=	**21853 m**

SUMMARY

The mechanical pedometer was successfully designed. It approximately met the design specifications for size. It was also able to measure more than the specified distance of 2 km and can actually measure about 21 km.

The disadvantage of this high range is that the accuracy gets reduced. It can measure only multiples of 22 m as this the digit number changes by 1 number only after 22 m or 66 steps. This can be solved by using a freewheel with less number of ratchet pegs. This reduces the least count but also reduces the range. Hence a balance between range and accuracy has to be reached based on the person's requirements.

Another method to increase sensitivity is to increase the angle of oscillation of the pendulum. This will make the freewheel to rotate by two or more divisions for a single step and the least count is reduced accordingly. For example, if the clearance is doubled the freewheel rotates by two divisions and least count reduces to 11 m. correspondingly the maximum range is also halved.

An advanced version can have two sets of gears, one for low-range high-accuracy and another for high-range low-accuracy. The user can switch between these gears based on his requirements.

REFERENCES

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    - Odometer
    - Bicycle Freewheel
- Machine Design – Norton
- Mechanical Engineering Design – Shigley