Creative Design of a Device That Not Only Cleans the Teeth but Also Anti-Germinates

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

Mechanical Engineering

By

R Murali & Pradeep Shantharam

Under the guidance of:

Professor Dr. S.K.Sahoo

Department of Mechanical Engineering

National Institute of Technology

Rourkela

2007

National Institute of Technology

Rourkela

CERTIFICATE

This is to certify that the thesis entitled **"Creative Design of a Device That not only Cleans the Teeth but also Anti-Germinates''** submitted by **R.Murali**, **Roll No: 10303044 and S.Pradeep, Roll No: 10303061** in the partial fulfilment of the requirement for the degree of **Bachelor of Technology** in **Mechanical Engineering**, National Institute of Technology, Rourkela, is being carried out under my supervision.

To the best of my knowledge the matter embodied in the thesis has not been submitted to any other university/institute for the award of any degree or diploma.

Date **Professor Dr. S.K.Sahoo**

Department of Mechanical Engineering
National Institute of Technology
Rourkela-769008

Acknowledgment

We avail this opportunity to extend our hearty indebtedness to our guide **Professor Dr. S. K. Sahoo**, Mechanical Engineering Department, for his valuable guidance, constant encouragement and kind help at different stages for the execution of this dissertation work.

We also express our sincere gratitude to **Dr. B. K. Nanda**, Head of the Department, Mechanical Engineering, for providing valuable departmental facilities.

Submitted by:

R Murali
Roll No: 10303044
Mechanical Engineering
National Institute of Technology
Rourkela

Pradeep Shantharam
Roll No: 10303061
Mechanical Engineering
National Institute of Technology
Rourkela

Abstract

In the past various methods have been found to clean the teeth but until recently not much importance has been given to the anti-germinating idea. After analyzing the causes of tooth decay the importance of anti-germinating has been found. Now there are various devices available to clean and anti-germinate the teeth but a system that combines both cleaning and anti-germinating has not been produced on a mass scale yet.

In this report we first study the history and evolution of cleaning the teeth. Then the various devices and chemicals used today to clean the teeth are analyzed. This is followed by the project analysis. Some designs that could provide a solution for the problem are found. Out of this the best design is found out considering factors like effort required, cost, efficiency, time. The various possible subsystems of the device are listed. The morphological analysis is then done. The most efficient and cost effective combination of subsystems is selected .This is the solution for the problem. The specification and size of the parts of the device is also given.

CONTENTS

LIST OF FIGURES AND TABLES

TABLES

FIGURES

Chapter 1

HISTORY

1. Evolution of Device to Clean and Anti-Germinate Teeth

In the beginning toothpicks, chew sticks, tree twigs, linen strips, birds' feathers, animal bones and porcupine quills were used to clean the teeth. The first toothbrush is believed to have been invented in China. In the Muslim world, the miswak or siwak made from a twig or root with antiseptic properties is widely used. Rubbing baking soda or chalk, charcoal, ashes against the teeth was also common. Limejuice, tobacco mixed with honey is also common. William Addis, England, is credited with creating the first mass-produced toothbrush in 1780.The first patent for a toothbrush was by H. N. Wadsworth in 1850 in the United States, mass production of the product in America started in 1885. The rather advanced design had a bone handle with holes bored into it for the Siberian Boar hair bristles. Boar wasn't an ideal material as it retained bacteria, it didn't dry well, and the bristles would often fall out of the brush. Natural bristles (from animal hair) were replaced by synthetic materials, usually nylon, by DuPont in 1938. The first nylon bristle toothbrush, made with nylon yarn, went on sale on February 24, 1938.The various advantages of nylon were low production costs, ability to control bristle texture and shape of filament tip and diameter could be varied.

The first electric toothbrush, the Broxodent, was introduced by Squibb Pharmaceutical at the centennial of the American Dental Association in 1959. In 1961, General Electric introduced a rechargeable cordless toothbrush that moved up and down when activated. In 1987, the first rotary action toothbrush for home use, the Interplak, was introduced. There are currently many different varieties of model that use this mechanism. Research shows that these may prove more effective at removing plaque and preventing gingival bleeding than manual toothbrushes.

The earliest known reference to a toothpaste is in a manuscript from Egypt in the 4th century A.D., which prescribes a mixture of powdered salt, pepper, mint leaves, and iris flowers. The Romans used toothpaste formulations based on human urine. Since urine contains ammonia, it was probably effective in whitening teeth. In the early 1800s, the toothbrush was usually used only with water, but tooth powders soon gained popularity. Most were homemade, with chalk, pulverized brick, and salt being common ingredients. An 1866 Home Encyclopedia recommended pulverized charcoal, and cautioned that many patented tooth powders then commercially marketed did more harm than good.

By 1900, a paste made of hydrogen peroxide and baking soda was recommended. Pre-mixed toothpastes were first marketed in the 19th century, but did not surpass the popularity of tooth-powder until World War I. In New York City in 1896, Colgate & Company manufactured toothpaste in the first collapsible tube, similar to that recently introduced for artists' paints. Fluoride started to be added to toothpastes in 1914, but while the early use of fluoride was criticized by the American Dental Association (ADA) in 1937, fluoride toothpastes developed in the 1950s got the ADA's seal of approval. Countries limit and suggest different amounts acceptable for health. Toothpaste is most commonly sold in flexible tubes, though harder containers are available. The hard containers stand straight up, availing more of the toothpaste and saving shelf space.

Chapter 2

CAUSES OF TOOTH DECAY

2. Causes of Tooth Decay

The plaque formed by the bacteria is the main reason for tooth decay. Bacteria - tiny colonies of living organisms are constantly on the move on the teeth, gums, lips and tongue. While some of the bacteria can be harmful, most are not and some are even helpful. Certain types of bacteria, however, can attach themselves to hard surfaces like the enamel that covers your teeth. If they're not removed, they multiply and grow in number until a colony forms. More bacteria of different types attach to the colony already growing on the tooth enamel. Proteins that are present in your saliva (spit) also mix in and the bacteria colony becomes a whitish film on the tooth. This film is called plaque, and it's what causes cavities. Plaque also produces substances that irritate the gums, making them red, tender or bleed easily. After a while, gums may pull away from the teeth. Pockets form and fill with more bacteria and pus. If the gums are not treated, the bone around the teeth can be destroyed. The teeth may become loose or have to be removed. The mouth is a dark, moist environment of a constant warm temperature with a steady supply of carbohydrates - truly ideal bacteria growing conditions. There are from 200 - 300 different species of bacteria in the mouth.

Bacteria can be divided into two types:
1. aerobic - those that live off and reproduce in air - mostly beneficial.
2. anaerobic - those that live in the absence of air - mostly pathological.

The excrement from the anaerobic bacteria is what you taste and smell in the mouth in the morning. Not only is it acidic, it also forms a sticky hydrophobic (water resistant) shield around the tooth, called plaque. This is why water alone does not work to remove plaque. In addition, gums act like a gasket around the tooth, further preventing air or water to reach the anaerobic bacteria along the gum line. Something else is needed to break through the grease barrier.

Bacteria (good or bad) reproduce exponentially every hour. This means that if there is a bacteria population of 1x (1x being the amount of bacteria in your mouth after a professional cleaning), after one hour you have doubled the population of bacteria, and after two hours you have 4x, then 8x, 16x, etc. Poor cleaning in a few areas will leave heavy concentrations of plaque that can repopulate other areas of the oral cavity. In addition, if you have a lot of restorations, crowns, bridges, orthodontic appliances, wisdom teeth, have periodontal disease, or don't floss, you start out with dangerous levels of bacteria even after you are through brushing your teeth.([3],[6])

Chapter 3

DEVICES AND SUBSTANCES USED TO CLEAN AND ANTI-GERMINATE TEETH AT PRESENT

3.1 Toothpaste

Toothpaste is a paste or gel used to clean and improve the aesthetic appearance and health of teeth. It is almost always used in conjunction with a toothbrush. Toothpaste use can promote good oral hygiene: it can aid in the removal of dental plaque and food from the teeth, it can aid in the elimination and/or masking of halitosis, and it can deliver active ingredients such as fluoride to prevent tooth and gum (Gingival) disease.

3.1.1 Ingredients and Flavours

Sodium fluoride (NaF) is the most popular active ingredient in toothpaste to prevent cavities; some brands use sodium monofluorophosphate (SMFP). Nearly all toothpaste have 1000 to 1100 parts per million fluoride ion from one of these active ingredients. Fluoride that is absorbed by your body is used by the cells that build your teeth to make stronger enamel. Topical fluoride - fluoride that is applied to the outside of the enamel - makes the crystals that form enamel more durable. Tooth enamel crystals that have fluoride are much more resistant to acid. They are less likely to breakdown and cause the tooth surface to become porous.

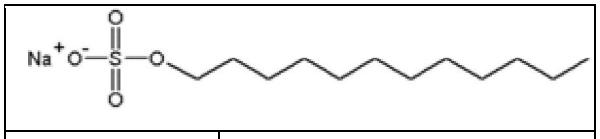
Many, toothpastes contain sodium lauryl sulfate (SLS) or another of the sulfate family. SLS is found in other personal care products as well, such as shampoo, and is largely a foaming agent. SLS may cause a greater frequency of mouth ulcers in some people as it can dry out the protective layer of oral tissues causing the underlying tissues to become damaged. Some brands include powdered white mica. This acts as a mild abrasive to aid polishing of the tooth surface, and also adds a cosmetically-pleasing glittery shimmer to the paste.

Sodium dodecyl sulfate (**SDS** or NaDS)

($CH_3(CH_2)_{11}OSO_3Na$) (FW 288.38), also known as **sodium lauryl sulfate** (SLS), is an ionic surfactant that is used in household products such as toothpastes, shampoos, shaving foams and bubble baths for its thickening effect and its ability to create a lather. The molecule has a tail of 12 carbon atoms, attached to a sulfate group, giving the molecule the amphiphilic properties required of a detergent.

It is prepared by sulphation of 1-dodecanol (lauryl alcohol, $CH_3(CH_2)_{10}CH_2OH$) followed by neutralizations with sodium carbonate. It is used in both industrially produced and home-made cosmetics. Like all detergent surfactants

(Including soaps), it removes oils from the skin, and can cause skin irritation. It is also irritating to the eyes. Ingredients such as baking soda, enzymes, vitamins, herbs, calcium, mouthwash , and/or hydrogen peroxide are often combined into base mixes and marketed as being beneficial. Some manufacturers add antibacterial agents like triclosan or chloride.



Systematic name	Sodium dodecyl sulfate
Chemical formula	$CH_3(CH_2)_{11}OSO_3Na$
Molecular mass	288.4 g/mol
Melting point	206 °C

Table 3.1: SDS properties

Toothpaste comes in a variety of flavours, most often being some variation on mint (spearmint, peppermint, regular mint etc). Other more exotic flavours include: anise, apricot, bubblegum (marketed mostly to children), cinnamon, fennel, ginger, vanilla, lemon, orange, pine. Some are even unflavoured.

Toothpaste is not intended to be swallowed. Some Extended consumption while the teeth are forming can result in fluorosis. Calcium used in toothpaste can be derived from animal bones or from lime. Vegetarians prefer to use products free of any ingredients derived from animals. For this reason, in India toothpaste suitable for vegetarians has been introduced and has done extremely well.([6],[7])

3.2 Dental floss

Fig. 3.1: Dental Floss

Dental floss is a bundle of thin nylon filaments or a plastic (Teflon or polyethylene) ribbon used to remove food and plaque from teeth. The floss is inserted between the teeth and

scraped along the teeth sides, especially close to the gums. Dental floss comes both waxed and unwaxed. Levi Spear Parmly, a dentist from New Orleans, is credited with inventing a legendary form of dental floss. He had been recommending that people should clean their teeth with silk floss since 1815. Dental floss was produced by Codman and Shurtleft Company started producing in 1882. It was the human-usable unwaxed silk floss. In 1898, the Johnson & Johnson Corporation received the first patent for dental floss. Nylon floss was found to be better than silk because of its greater abrasion resistance and elasticity.

3.3 Toothbrushes

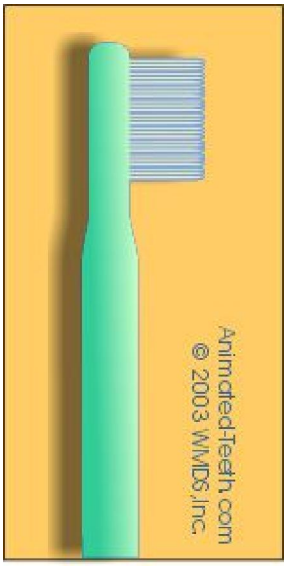


Fig. 3.2: Manual toothbrush

3.3.1 Manual Toothbrushes

These are simply the hand held, hand manipulated toothbrushes. When a manufacturer designs a manual toothbrush one of their goals is to create a brush whose bristles have the ability to reach difficult areas, such as those areas in between teeth or on the side of teeth down by the gum line. Most studies have concluded that there is no significant change in brushing effectiveness when differences in bristle design, texture, or brush shape are evaluated. However, for any one individual and related to their own specific situation and own individual brushing technique, one toothbrush design might be more effective or easier to use than another.

Manual tooth brushing can be very effective but it is extremely dependent on technique. The person brushing must:

- brush in the right directions, ...
- using the right motions, ...
- without too much force, ...
- for an appropriate amount of time (at least two minutes), ...

This is the reason why persons fail at brushing their teeth effectively with a manual toothbrush. Usually it's best to choose a manual toothbrush whose bristles have been categorized by its manufacturer as "soft." Toothbrushes having harsh bristles could possibly

clean away dental plaque more readily than their counter parts designed with softer bristles, but a stiff brush would likely also damage or abrade soft oral tissues.

3.3.2 Rotary Electric Toothbrushes

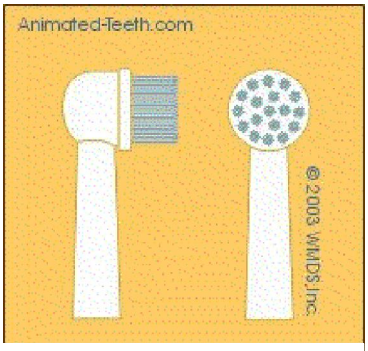


Fig. 3.3: Rotary Electric Toothbrush

Rotary electric toothbrushes are all similar by way of the fact that they each have a set of rotating bristles. These bristles are either arranged in a circular format that rotates or oscillates, or else the individual tufts of bristles contained in the brush head each possess a spinning motion. In most cases these brushes generate between 3,000 and 7,500 brush strokes per minute.

The plaque removing capability of rotary electric toothbrushes, in similar nature as with all toothbrushes that came before them, relies on the scrubbing motion of the brush's bristles on a tooth's surface .However these brushes often possess some ability to reach into the inter proximal (between the teeth) or sub gingival (below the gum line) regions in the mouth to some degree.

Studies that have evaluated rotary electric toothbrushes have produced a large amount of clinical evidence that shows that these brushes are superior to manual tooth brushing in regards to plaque removal and reduction in gingivitis (gum inflammation). These findings can probably be attributed to both the enhanced cleaning action of the bristle movements of these brushes, and the fact that the effective use of these brushes relies little on the dexterity of the individual using it. ([1],[6])

3.3.3 The Oscillating / Pulsating Rotary Electric Toothbrushes

Electric toothbrushes that have both an oscillating and pulsating motion, such as the Braun Oral B "3D" model brushes, are considered to be examples of the pinnacle of conventional electric toothbrush design. These brushes have a round brush head that is capable of oscillating back and forth at a rate of 7,600 brush strokes per minute. In addition to this motion the Braun Oral B company has incorporated a pulsating action which creates movements somewhere between 20,000 and 40,000 pulses per minute, depending on the specific brush model. The conventional mode of cleaning that is produced by these Braun

Oral B brushes however (that cleaning produced by the toothbrush's bristles scrubbing a tooth's surface) is exceptional.

3.3.4 Other Rotary Electric Toothbrushes

Previous decades have produced a variety of other rotary electric toothbrush designs. Some of these are:

3.3.4.1 Rota-dent Brand Toothbrushes

The tiny brush heads found on these brushes possess a single rotating tuft of bristles fashioned in either a pointed or cup-shaped form. The cup-shaped brushes are intended for use on larger tooth surfaces while the pointed brushes have been designed for use between teeth.

3.3.4.2 Interplak Brand Toothbrushes

These brushes are known as "counterrotational" toothbrushes. The brush head of these brushes looks similar to a standard manual toothbrush but each individual tuft of bristles on the brush head rotates, in opposite direction as its neighbour.

3.3.5 Sonic toothbrush / electric toothbrush

3.3.5.1 The Sonicare toothbrush

The most recent advancement in the design of electric toothbrushes was first incorporated into a product in 1983. This product was the Sonicare toothbrush. The class of electric toothbrushes that subsequently grew out of the use of this technology has now become known as the "sonic toothbrushes".

Sonic toothbrush can be identified by way of the high rate of speed at which its brush head vibrates. The brush head of a sonic toothbrush is capable of creating in excess of 30,000 brush strokes per minute. (The latest models of sonic toothbrushes can create more than 40,000 brush strokes per minute. In comparison conventional electric toothbrushes typically operate at frequencies ranging between 2,500 and 7,500 strokes per minute). It is the vibrational motion of these brushes that sets them apart from all previous generations of electric toothbrush design.

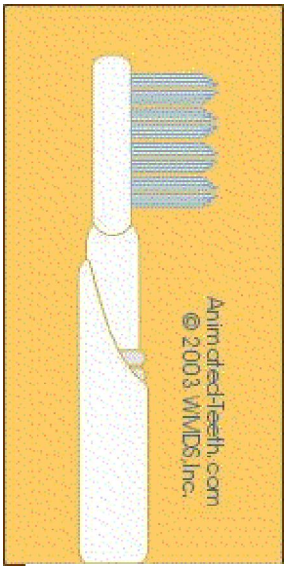


Fig. 3.4: Sonicare

The cleaning action generated by a Sonicare toothbrush is actually based on two separate mechanisms. One of these is conventional and is similar in nature to that mechanism employed by all other types of toothbrushes. The second cleaning action is based on a new technology that was first introduced by Sonicare and one that is entirely unique to sonic toothbrushes.

The primary mode of cleaning that a sonic toothbrush can provide is that which is produced by the scrubbing action of its brush head's bristles on the surface of the user's teeth. All toothbrushes, both electric and manual, rely on this same principle for removing dental plaque.

Sonicare toothbrushes are also capable of producing a secondary cleaning action, one based upon a new technology developed by the brush's creators. This cleaning action is founded on the intense speed at which the bristles of the sonic toothbrush vibrate. This vibratory motion is able to impart energy to the fluids that surround teeth (such as saliva). The motion of these agitated fluids is capable of dislodging dental plaque, even beyond where the bristles of the toothbrush actually touch. This high speed brushing action in turn creates turbulent fluid dynamics near the tips of its bristles. The result is the creation of waves of pressure and shear forces in the liquids that surround your teeth, and also the creation of minute bubbles that are propelled forcefully against surfaces where plaque resides. The combination of these various fluid dynamics results in forces that are capable of dislodging dental plaque in those hard to reach areas such as between teeth and below the gum line. The cleaning effect of these fluid forces has been measured to occur at distances of up to 4 millimetres (slightly more than 1/8th of an inch) beyond where the bristles of your sonic toothbrush actually touch. The fluid dynamics cleaning action produced by a sonic toothbrush is considered to be one of secondary importance. It augments and enhances that cleaning activity created by the conventional scrubbing action of the toothbrush's bristles on the surface of teeth.

One study was conducted (our Stanford et al reference) where tooth enamel samples were allowed to accumulate a film of dental plaque. These samples were then exposed to the brushing action of either a Sonicare ® toothbrush or toothbrush. After this brushing period the enamel samples were evaluated for cleanliness by way of viewing them under a scanning electron microscope. Here's what the study found:

Variation #1: The toothbrush was held in direct contact with the enamel sample. 95% of the dental plaque was dislodged if the contact between the brush and the enamel surface was for duration of at least 5 seconds. If the contact time was 10 seconds or longer all of the dental plaque was removed.

Variation #2: The toothbrush was held 2mm from the surface of the enamel sample surface. [No direct contact between the brush and the enamel sample surface.] 65% of the dental plaque was removed by the fluid forces generated by the brush when it was held at this distance for at least 5 seconds.

Variation #3: The toothbrush was held 3mm from the surface of the enamel sample surface. [No direct contact]. The fluid forces that were generated by the brush were able to produce 58% plaque reduction at 5 seconds, 63% plaque reduction at 10 seconds, and 76% plaque reduction at 15 seconds.([2], [6],[7])

3.3.5.2 The Charge

The electronic compartments in the electronic toothbrushes are completely sealed to prevent water damage. There are no metal contacts. These toothbrushes charge using a technique called inductive charging. In the brush unit is one half of a transformer, and in the charge-unit is the other part of the transformer. If you put these together, the charge can flow.

3.4 Dental air force

Dental air force® home dental cleaning system is an innovative appliance that is a completely new way to clean your teeth between professional cleanings. The appliance uses a precision jet of air to deliver water and dental cleaner to "power wash" wash teeth, between teeth and along the gum line. Plaque and odour are removed from teeth, in between teeth and around the gum line.

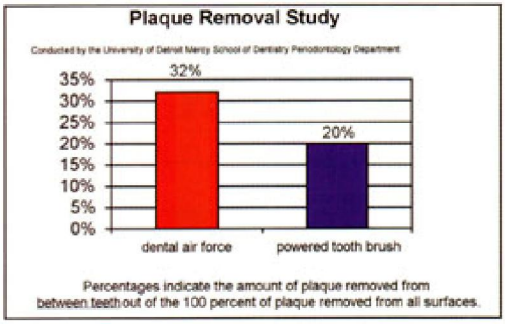


Fig. 3.5: Dental Air Force

University clinical studies show the system's abrasivity is at a safe level and is uniform on cheek-side, tongue-side and between teeth surfaces. It is particularly effective for patients with crowns, bridges and orthodontic appliances. Dental air force uniquely dispenses the dental cleaner in a controlled and consistent application. One normal application uses one cup of dental cleaner. The cleaner ingredients include sodium bicarbonate, the most widely accepted and totally natural buffering agent that promotes a neutral environment. It also contains mint flavouring and xylitol. The formula is free of sodium laurel sulphate, the ingredient in most toothpaste that causes sensitivity and irritation. . You can use the system with hydrogen peroxide and get the added benefit of intrinsically whitening your teeth and further oxygenating, disinfecting and destroying the anaerobic species of bacteria. Dental air force® breaks through the sticky shield, aerates the site and neutralizes the acid, thus reducing the pathological anaerobic bacteria on all surfaces of the teeth.

Normal cleaning methods like brushing and flossing have a difficult time accessing the sites between the teeth, aerating those sites, and neutralizing the acid where the anaerobic bacteria thrive. **dental air force®** is a tool to provide you with thorough cleaning every day and a low average count of plaque on all surfaces of teeth - cheek side, tongue side, between teeth and around the gum line. Voracious tooth brushing can over abrades the cheek surface of the teeth along the gum line, causing ridges and sensitivity to hot, cold, sweets, and further brushing. In a clinical study conducted by the University of Detroit Mercy School of Dentistry, dental air force® removed 62.5% more plaque between teeth than the leading power toothbrush. It did this while being three times less abrasive on the cheek side surfaces of the teeth.([5])

Chapter 4

PROJECT ANALYSIS

4.1 Realization of need

- To clean teeth by removing plaque
- To prevent occurrence of bacteria
- To prevent tooth decay
- To maintain mouth clean and to anti germinate it

4.2 Need Analysis

- To clean and anti germinate the teeth

4.3 Anti-Germination

- Process of destroying the bacteria present in the mouth and to prevent its occurrence

4.4 Methods to Anti-Germinate the Teeth

- To use chemicals to disinfect teeth
- To aerate the area to destroy the anaerobic bacteria
- To maintain teeth clean by reducing formation of bacteria by eating a balanced diet

4.5 Cleaning

- Process of removing bacteria found on teeth

4.6 Methods to Clean Teeth

- To use chemicals to remove bacteria
- To use abrasive action to dislodge it like scrubbing
- To force it out using a jet of liquids
- To remove it by imparting kinetic energy to saliva

4.7 Methods used to find solution of the problem

- The various alternatives available today for cleaning and anti-germinating the teeth is found

- The new alternatives for the cleaning and anti-germinating is found out using imagination
- The evaluation of alternatives is done based upon certain factors such as cost, reliability, easiness etc
- Using the evaluation the best alternative is found out
- The various sub systems present in the chosen alternative is found and analysed
- The alternatives of the sub-system is got and its feasibility is found out by using the morphological analysis
- The various available solutions are got and compatibles are selected
- the best one is selected to get the solution for the problem given

Chapter 5

DESIGNS

5.1 Brush with Two Rotating Heads (A)

Here the brush has two heads. Either one can be rotated by using the switch. The circular headed one is used for normal brushing. The sharp pointed one is used to reach the areas difficult to reach with the other head. This is operated using a motor, shaft, bevel gears as shown in figure. This also has a replaceable tube filled with anti-germinant which on squeezing releases anti germinant from one of the heads.

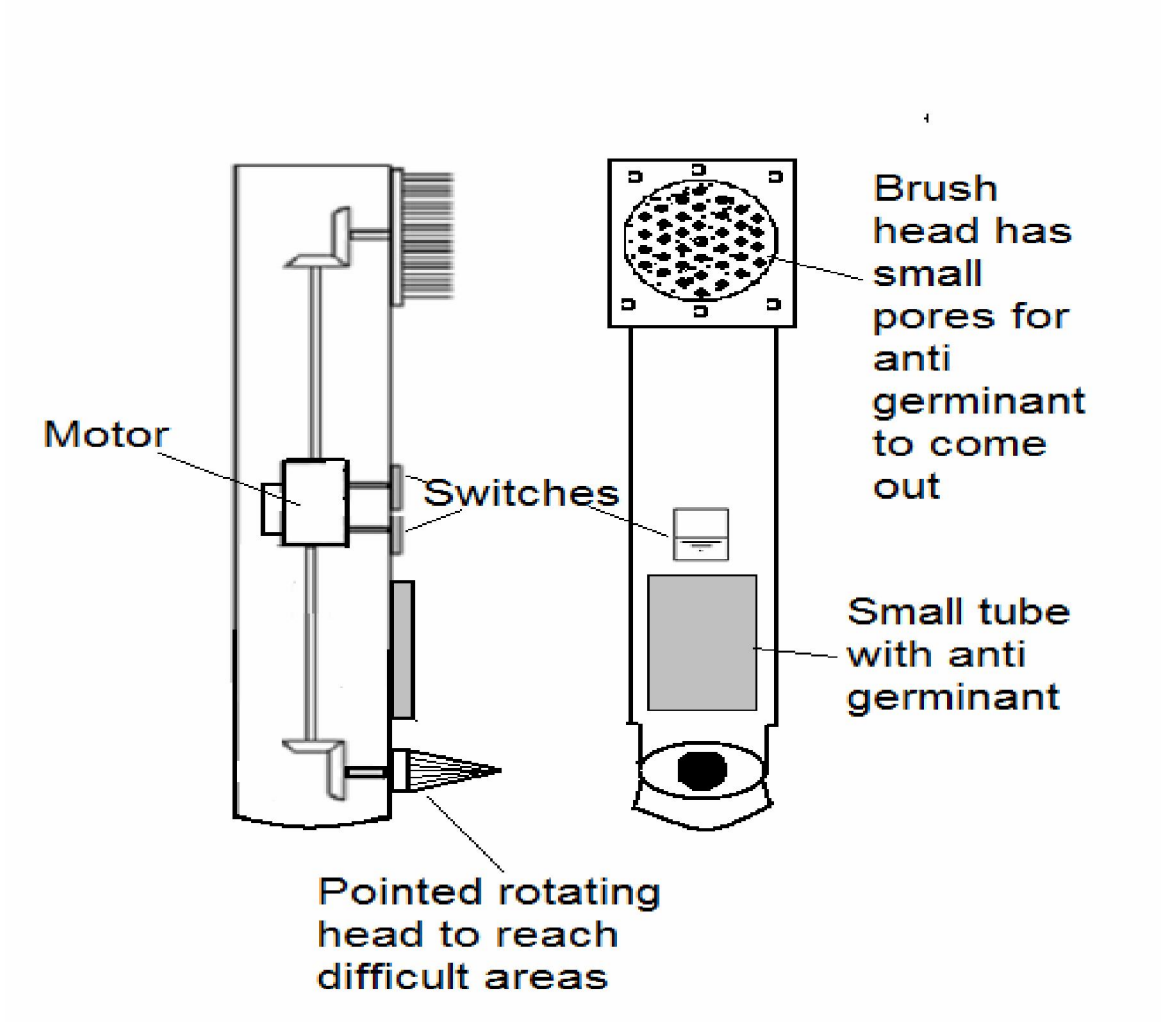


Fig. 5.1: Brush with Two Rotating Heads

5.2 Spray able Anti Germinant and Cleaning Agent (B)

Here the anti germinant and the cleaning agent mixture is pressurised and filled in the cylinder. Using the nozzle the solution is sprayed in the mouth. Various different types of nozzles are provided to reach different areas of the mouth. The cylinder is to be replaced after it gets empty. The press knob is used to spray the anti germinant and cleaning agent.

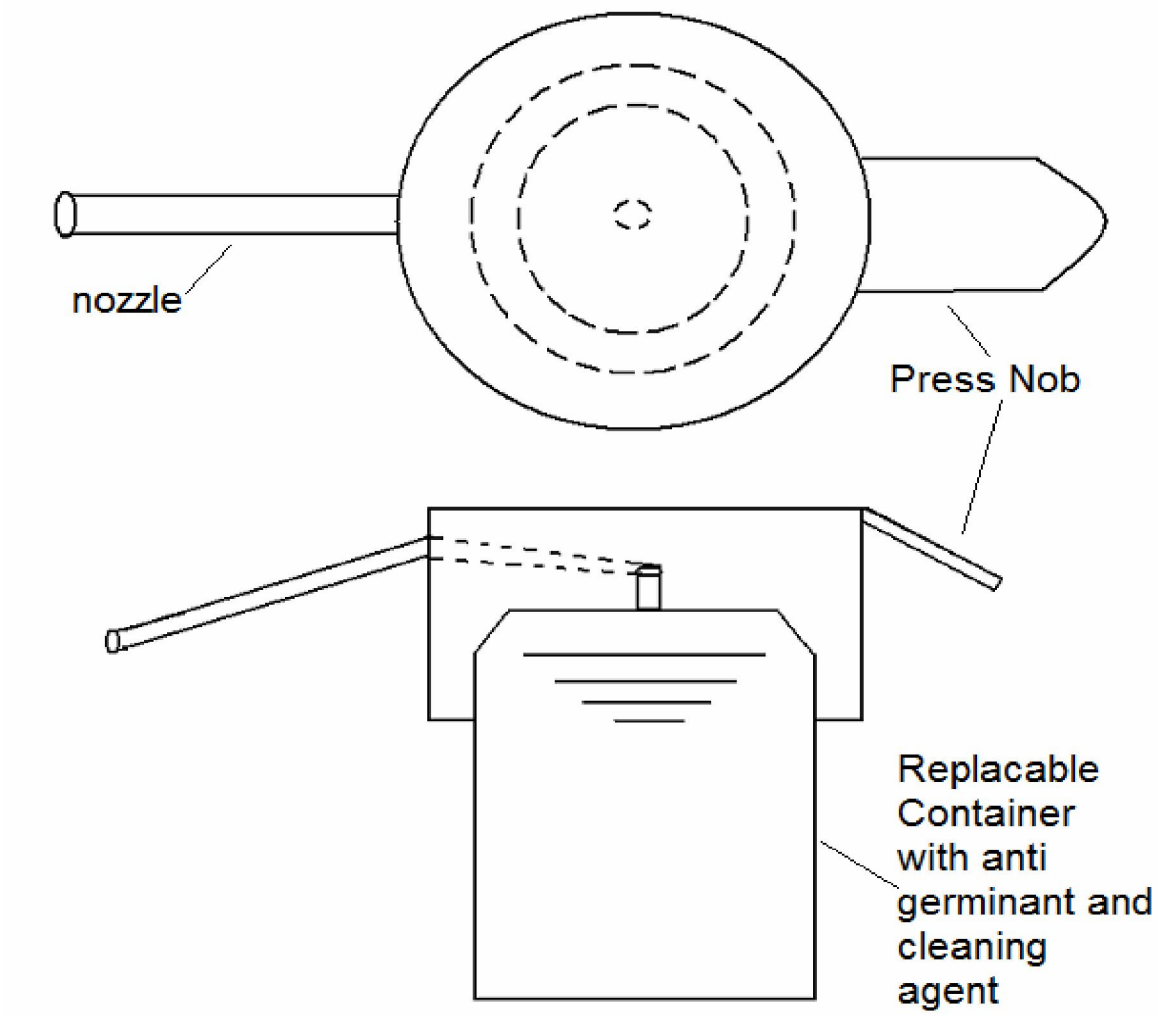


Fig. 5.2: Spray able Anti Germinant and Cleaning Agent

5.3 Ordinary Rotating Brush With Anti Germinant (C)

This is an ordinary rotating toothbrush which rotates with the help of bevel gears. This also has a replaceable tube filled with anti germinant. On squeezing this, the anti germinant comes out of the head.

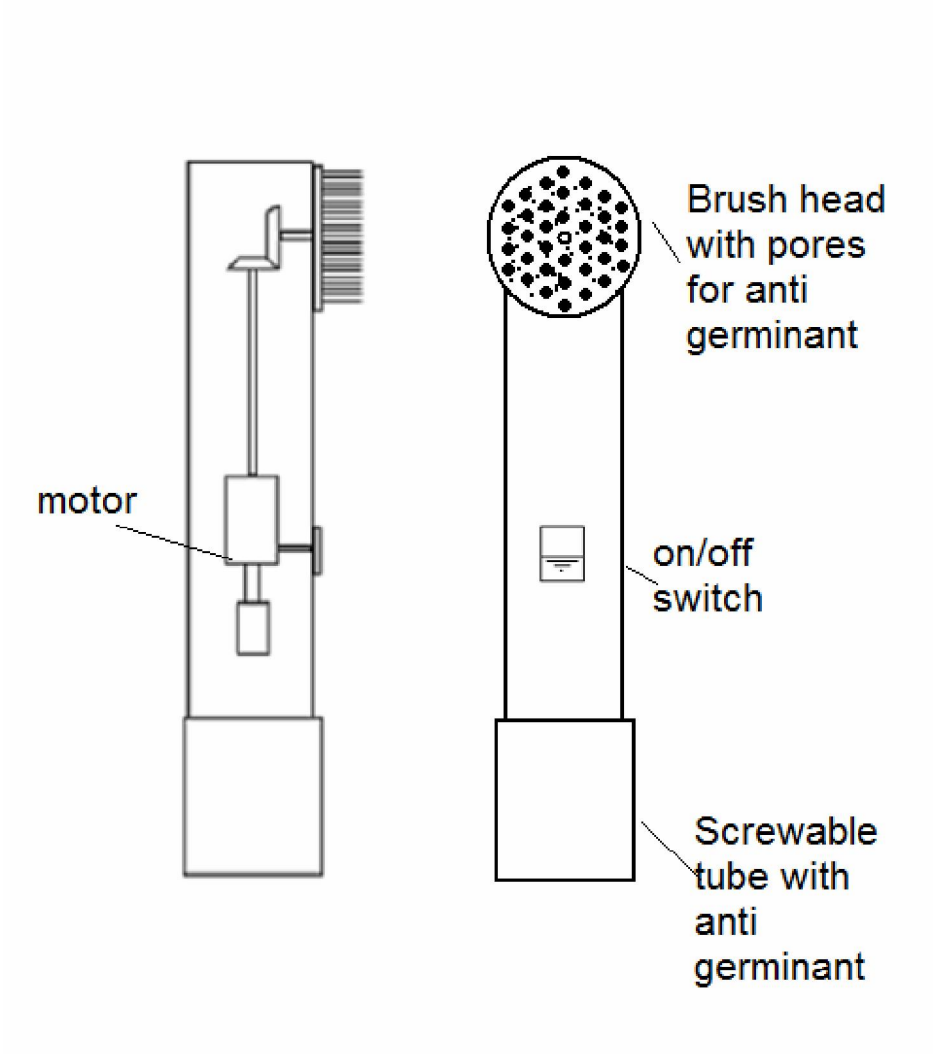


Fig. 5.3: Ordinary Rotating Brush With Anti Germinant

5.4 Spindle Type Rotating Toothbrush (D)

Here the brush is in the rotating shaft. The bristles are attached to the hollow shaft. The shaft is sealed on one end and has pores at the bristles to secrete the anti germinant. One side of the spindle is sealed with a protective cap to protect the gums. The shaft can be rotated in clockwise or anti-clockwise direction as wanted by using the switch.

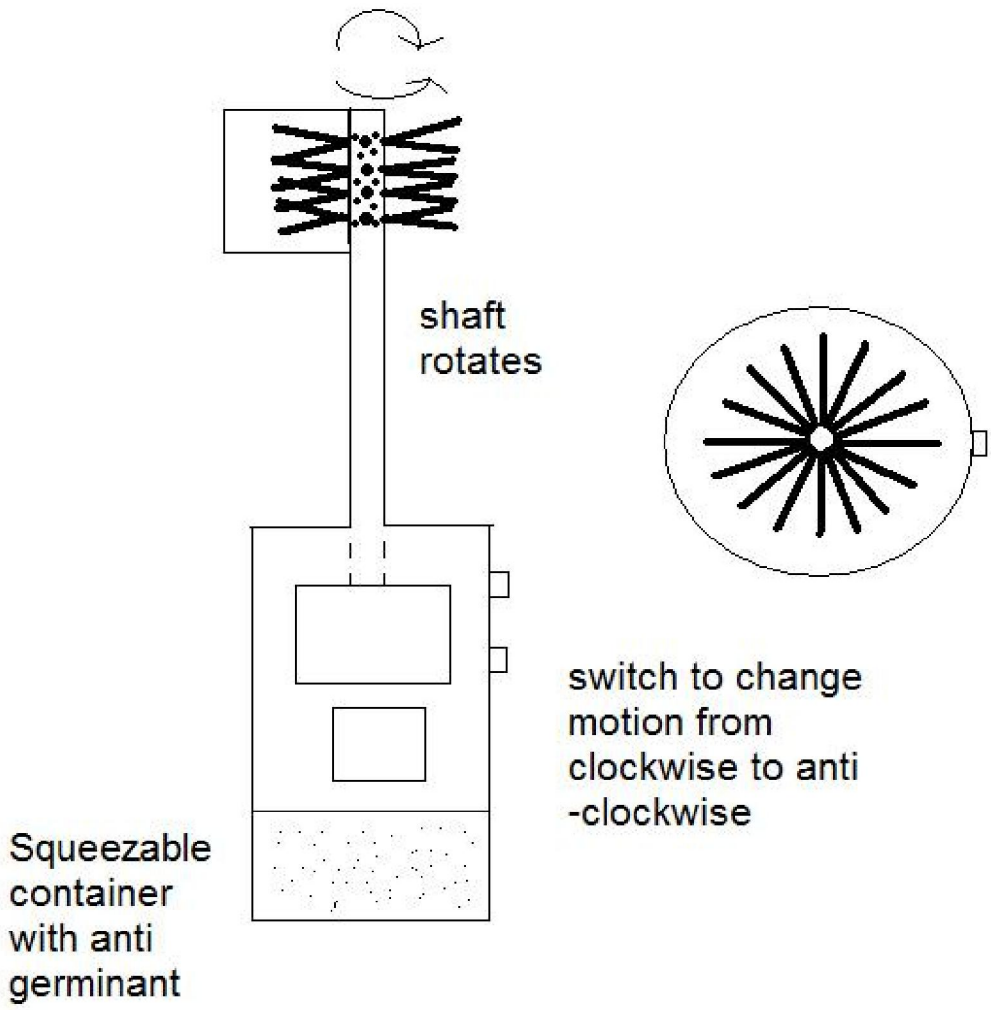


Fig. 5.4: Spindle Type Rotating Toothbrush

5.5 Manual Brush with Movable Set of Bristles (E)

Here the set of bristles are placed in grooves as shown in the figure. There are pores in the grooves out of which the anti germinant comes out on applying pressure at the supply container. When the brush is moved back and forth the bristles moves up and down in the grooves and cleaning difficult to reach areas.

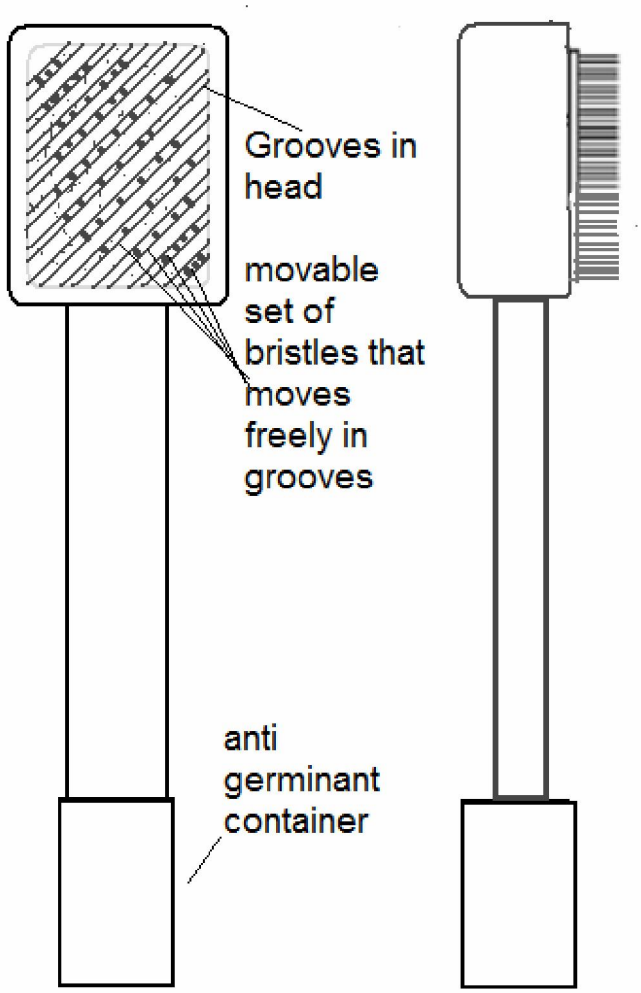


Fig. 5.5: Manual Brush with Movable Set of Bristles

5.6 Manual Toothbrush with Three Brush Heads (F)

This brush has three sets of brush heads on two axes as shown in the figure. The handle can rotate about the brush head as shown in the figure. The pores for outlet of anti germinant is present only at the base; bottom set of bristles. The handle rotates freely about the axis of brush head as in figure.

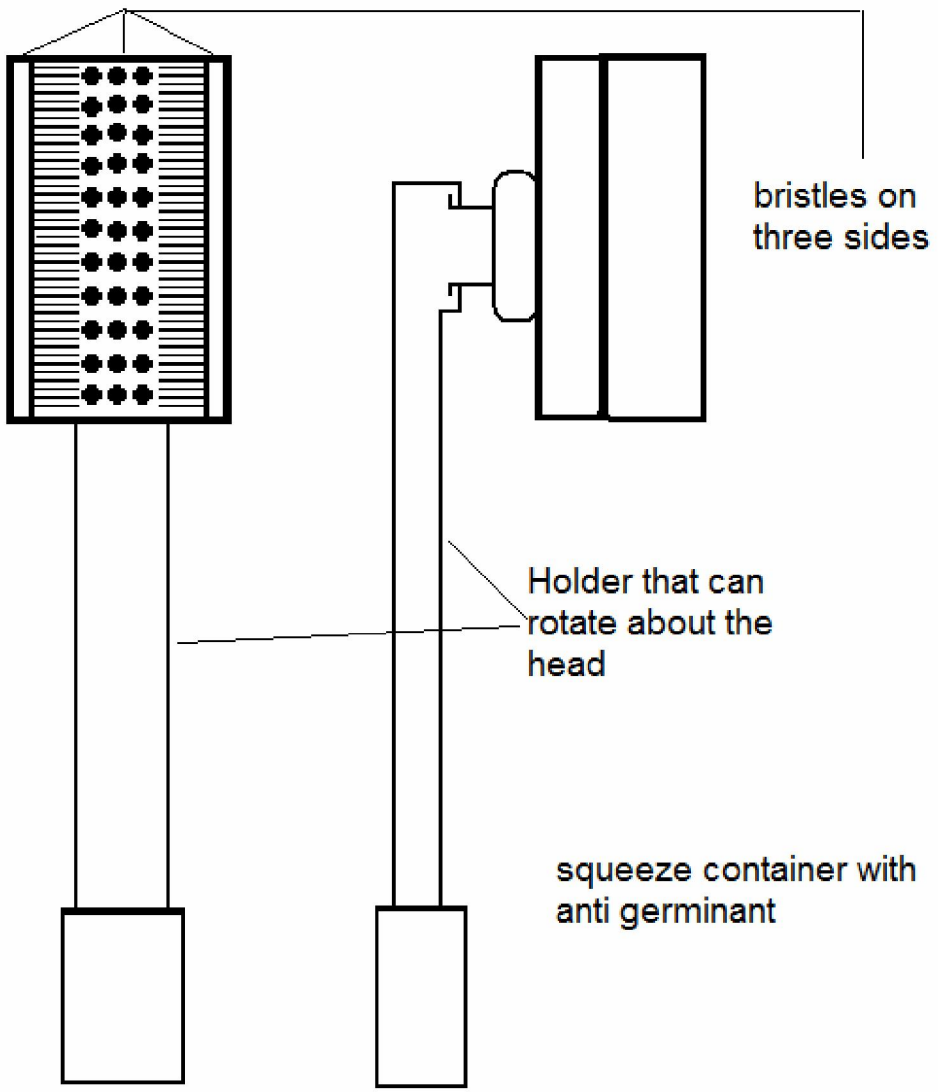


Fig. 5.6: Manual Toothbrush with Three Brush Heads

5.7 Octagonal Toothbrush (G)

This brush has a head which rotates in clockwise motion .The bristles present in the head are made to undergo to and fro motion as shown in the figure. The combined effort of the to and fro motion and the rotation of the brush head increases the efficiency of the toothbrush. This also has a button for ejection of anti germinant when required.

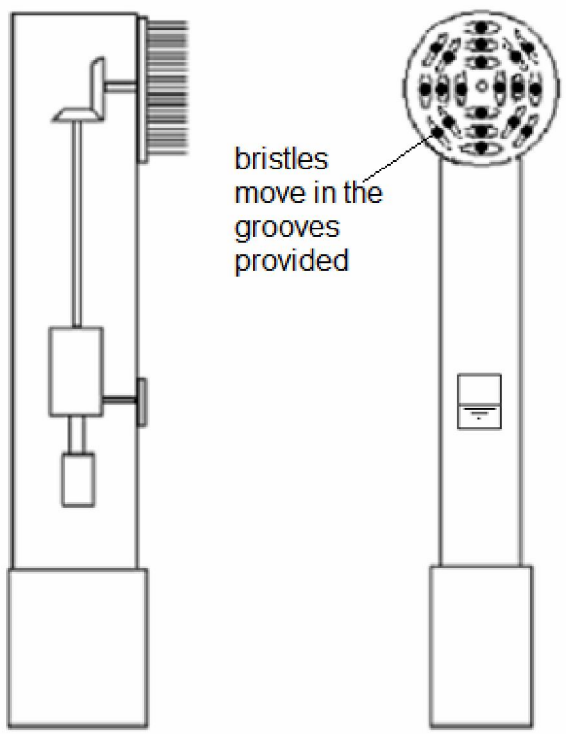


Fig. 5.7: Octagonal Toothbrush

5.8 Spring Type Toothbrush (H)

This is a brush which has two springs as shown in the figure connected over a pulley by a wire. Using the holder given one of the springs is compressed fully and is released. This produces alternate clockwise and anti clockwise motion in the brush head. This motion simplifies the effort required in brushing. This also has anti germinant container.

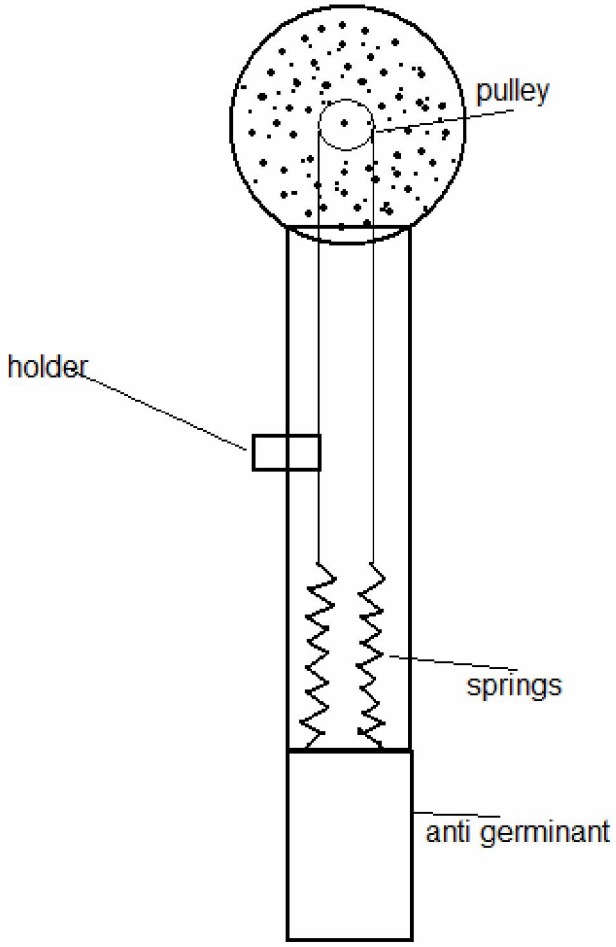


Fig. 5.8: Spring Type Toothbrush

Chapter 6

EVALUATION

Evaluation.

DESIGN	EFFORT REQD.	COST	TIME	SPECIAL FEATURES	EFFICIENCY
A	low	high	low	It has two rotating heads, so that the farthest ends can be reached. Anti-germinant is also inbuilt in the brush.	high
B	low	medium	medium	It is easy to use, no effort required. Anti-germinant is also inbuilt in the brush.	medium
C	medium	high	low	It has an electrically operated rotating head. Anti-germinant is also inbuilt in the brush.	high
D	medium	medium	medium	It has a rotating head which can rotate in both directions. Anti-germinant is also inbuilt in the brush.	high
E	high	low	medium	Here bristles can also move along their slots, effectively giving secondary cleaning. Anti-germinant is also inbuilt in the brush.	medium
F	medium	medium	low	It has three sets of bristles to clean all round the teeth in one turn itself. Anti-germinant is also inbuilt in the brush.	high
G	low	high	low	It has a rotating head with movable bristles. Anti-germinant is also inbuilt in the brush.	high
H	medium	low	medium	It has spring motion which produces rotation in both directions. Anti-germinant is also inbuilt in the brush.	medium

Table 6.1: Evaluation

Design A is selected as the best design

Chapter 7

IDENTIFICATION OF SUB SYSTEMS

7. Identification of the Subcomponents of the best design

There are various subsystem functions or components. They are,

i. The rotating system
ii. The system for power
iii. On-off circuit
iv. Bristles
v. Body of the tooth brush
vi. Speed varying circuit
vii. The motion system
viii. The cleaning fluid or paste
ix. Storage system of cleaning fluid/paste
x. Subsystem to only rotate any one brush head

Each subsystem tends to have an alternative.

7.1 The rotating system

7.1.1 High speed motor

This tends to have higher speeds of rotation greater than 7000 rpm. This also has higher power consumption.

7.1.2 Low speed motor

This tends to produce speeds lesser than 3000 rpm consumes less power

7.1.3 Medium speed motor

This has speeds between 3000-7000 rpm. This reaches a compromise of power and speed. The motor is a DC motor. Has a general power consumption of about 2W.

7.2 The System for power

Normally **two AA sized batteries** are used with a electric tooth brush to supply power. This increases the size of wire and weight of a brush.

A **nine volt single battery** can also be used. This occupies lesser volume.

7.3 On-off circuit

The on-off circuit can be carried out by using switches like **see-saw switch** or **push button switch**

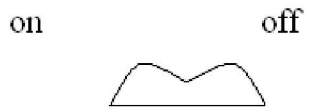


Fig. 7.1: See saw switch

Fig. 7.2: Push button switch

The type of the switch depends on the ease of operation and longer life.

7.4 Bristles

These play an effective role in the cleaning of the teeth. The bristles can be many of the designs like

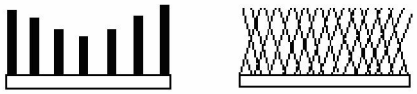


Fig. 7.3: Bristles

These are some of the common types. The bristles can also be soft or normal in its hardness. Generally this is based upon the age groups.

7.5 The body of the tooth brush

The look, feel of the brush is very important. The holding must be comfortable. The body can be designed by keeping in mind, the age group using it. For youngsters the body is usually made attractive. For middle aged people it is made simple and comfortable. For older people rubberised cushion is used on the body to help them hold it easily.

7.6 Speed varying circuit

Speed can be varied by changing the power supplied to the motor used.

The **sliding switch** like this one can be used to vary the speeds.

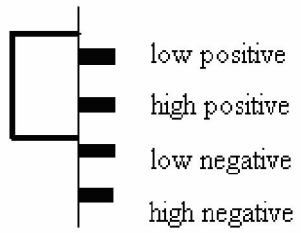


Fig. 7.4: Sliding Switch

Or all the on-off and speed varying can be integrated into a single sliding switch like

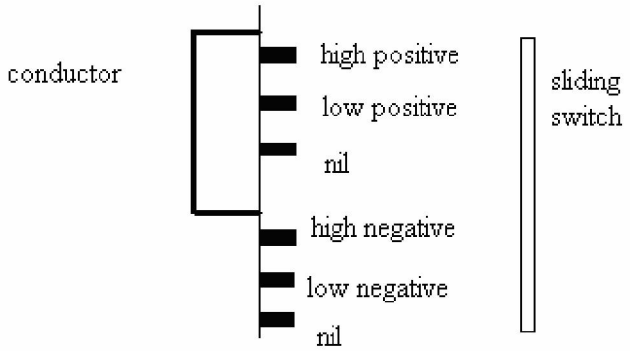


Fig. 7.5: Single Sliding Switch

A see saw switch can also be used here

7.7 The motor transmitting system

The motion from the motor is transmitted to the bristles here.

Simple set of gears can be used

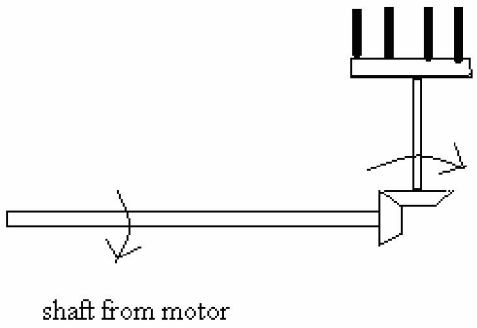


Fig. 7.6: Transmission System

A crank shaft can be also used for alternating motion

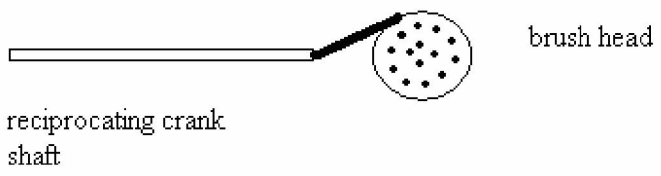


Fig. 7.7: Transmission using Crank Shaft

Here the rod is fixed at two ends and is held at the centre with an elastic support on rotation of the shaft it transmits oscillatory motion to brush head.

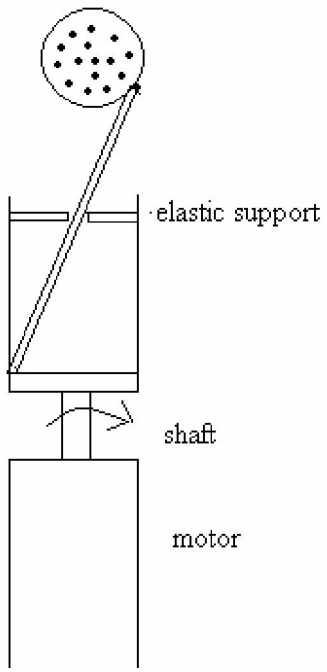


Fig. 7.8: Shaft Transmitting Oscillatory motion to Brush-head

The brush head can also be imparted oscillatory motion as shown in the figure by using a slider pin and guide slot.

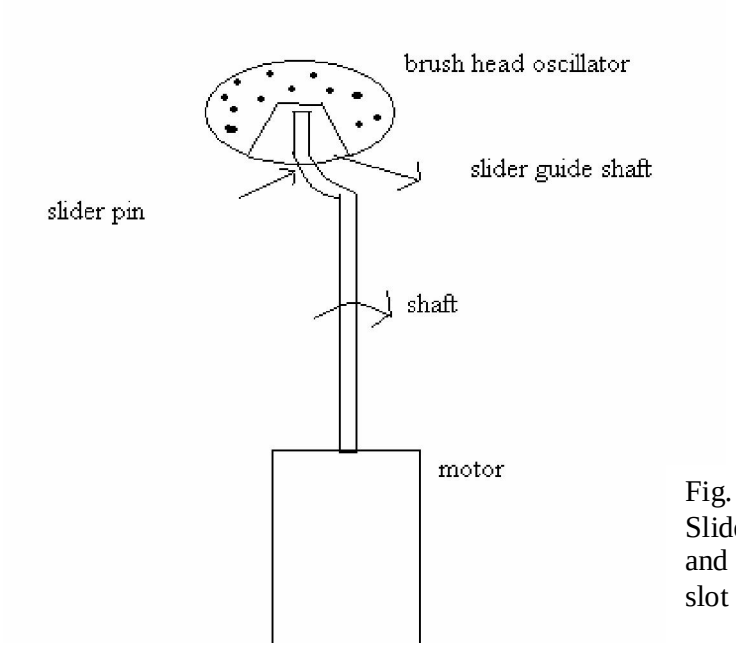


Fig. 7.9: Slider Pin and Guide slot

7.8 The cleaning fluid or paste

This is a mixture of ingredients. It mainly has fluoride in it (Sodium fluoride). It has about 1000 parts per million of fluoride. It uses a foaming agent no sodium lauryl sulphate is used. Alcohol and tricosine is also used.

7.9 The storage system of fluid

This must be of transparent container to show level of fluid. The system encloses the entire tooth brush actually. It lies inside a rubber lining which helps in squeezing. The motor unit is completely sealed so there is no change of a leakage.

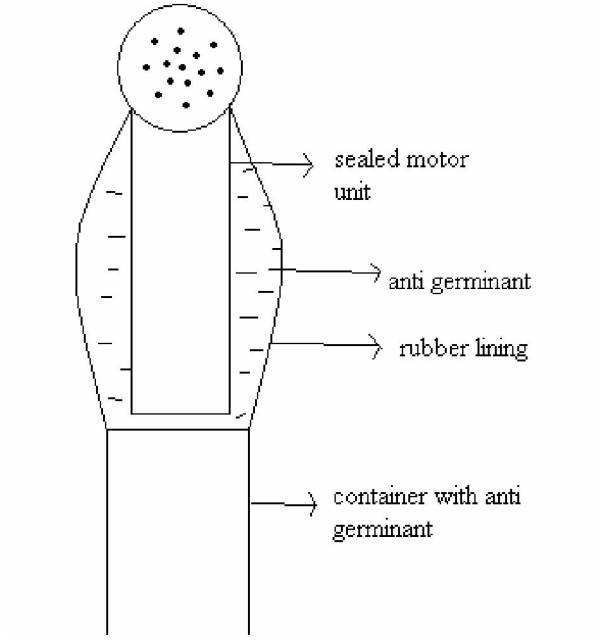


Fig. 7.10: Anti-germinant storage system

7.10 Sub system to rotate any one brush head

On moving the switch any one head can be engaged.

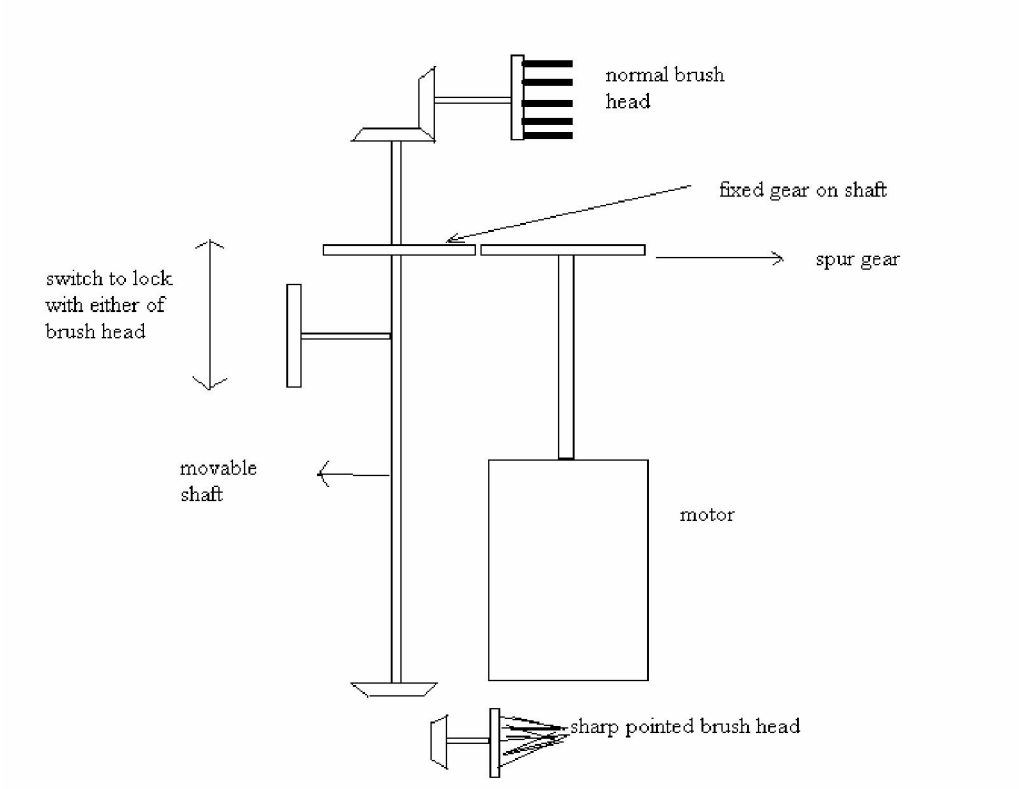


Fig. 7.11: Sub-system to rotate any brush head

Chapter 8

MORPHOLOGICAL ANALYSIS

8. Morphological Analysis

Subsystem	Alternative 1	Alternative 2	Alternative 3	Alternative 4
System for rotation(A)	High speed motor	Low speed motor	Medium speed motor	
System for power(B)	Two AA sized batteries	Single 9 volt batteries		
On-off circuit(C)	See-saw switch	Push button type	Sliding type	
Bristles(D)	Soft	Normal		
Body of the tooth brush(E)	To look attractive	Simple	Rubberised, Comfortable	
Speed varying circuit(F)	Sliding type			
The motion transmitting system(G)	Simple gear assembly	Crank shaft reciprocating	Oscillators 1	Oscillators 2
The cleaning fluid or paste(H)	Flouride, Soldium lauryl sulphate			
Storage system Cleaning fluid(I)	A rubber container			
Subsystem to only rotate a brush head(J)	Gear assembly1			

Table 8.1: Morphological Analysis

Now the morphological analysis has been done. So the result the most compatible solution is obtained from the various combinations of the different possibilities of the sub-systems

The various solutions available are

=3*2*3*2*3*1*4*1*1*1

=27*16=144

The best system is got from 144 possibilities.

The best system is

A1-B2-C3-D2-E1-F1-G3-H1-I1-J1

This is the most efficient system. It is also the most costly system. It is also the most expensive one. This has a speed varying circuit. It employs a high speed motor and has high

power consumption. So it is a single volt battery. Here both the brush heads rotate to give maximum cleaning efficiency. Because of the cost consideration this is not selected as the most optimum design.

But considering economy and cost-effectiveness

The most compatible design is

A3-B2-C2-D2-E3-G3-H1-I1

This is a cost effective and simple system which is efficient. This is the best option. This does not have two rotating heads one rotates while other is fixed .The fixed one is a sharp pointed one which can be used to clean the inner side of the teeth. The other head can be used to clean other surfaces of the teeth. This design compromises between cost effectiveness and efficiency.

The parts present in this system are

i. A Medium speed motor
ii. Single 9 volt battery
iii. Push button type circuit
iv. Bristles can be soft/medium (normal)
v. Normal looking comfortable, rubberised
vi. Oscillator mechanism as shown before
vii. A cleaning fluid
viii. A rubberised container to hold the anti-germinant.

Chapter 9

THE FINAL DESIGN

9. The Final Design

9.1 Half sectional top view

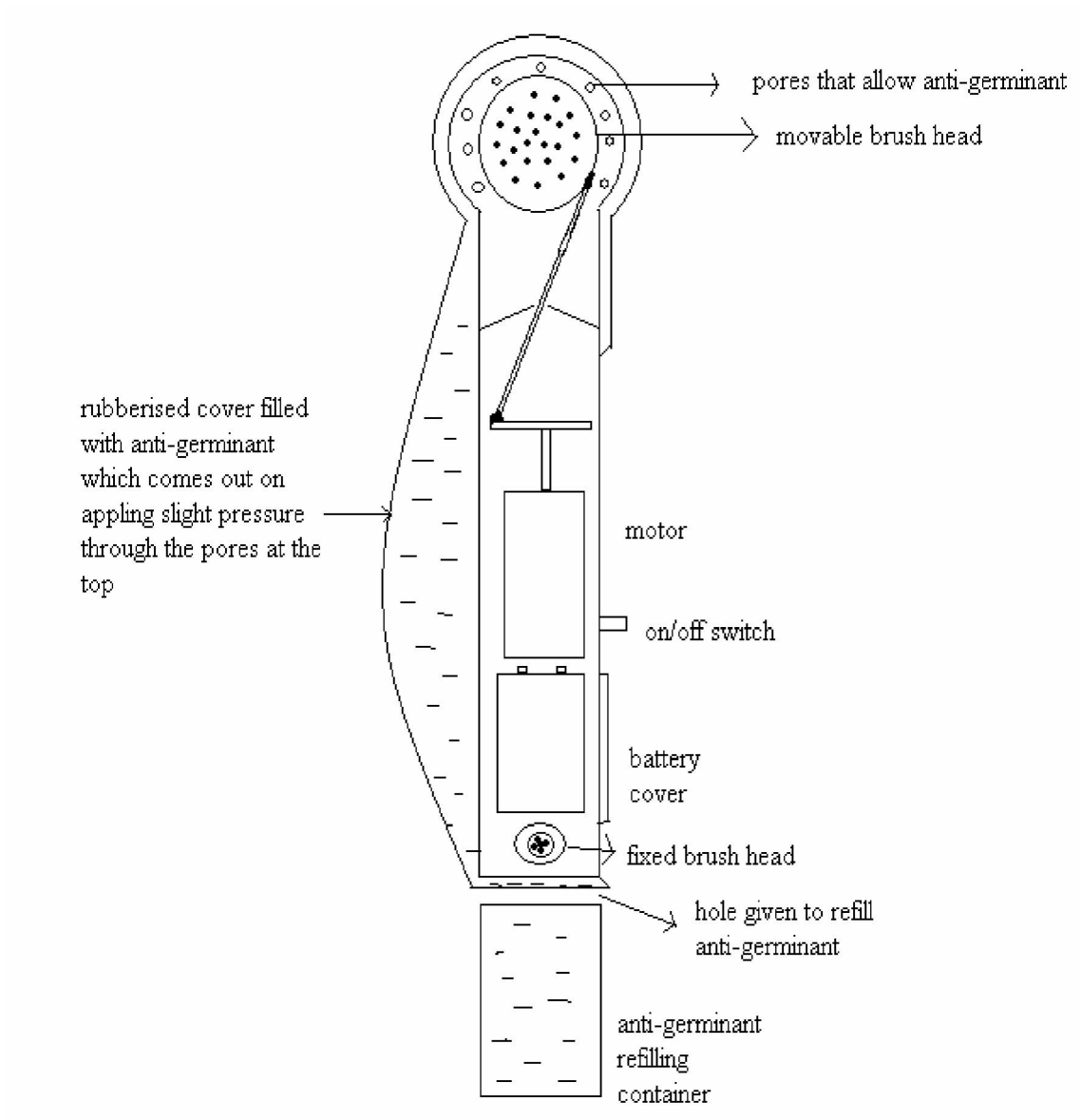


Fig. 9.1: Half- Sectional Top view

9.2 Top view

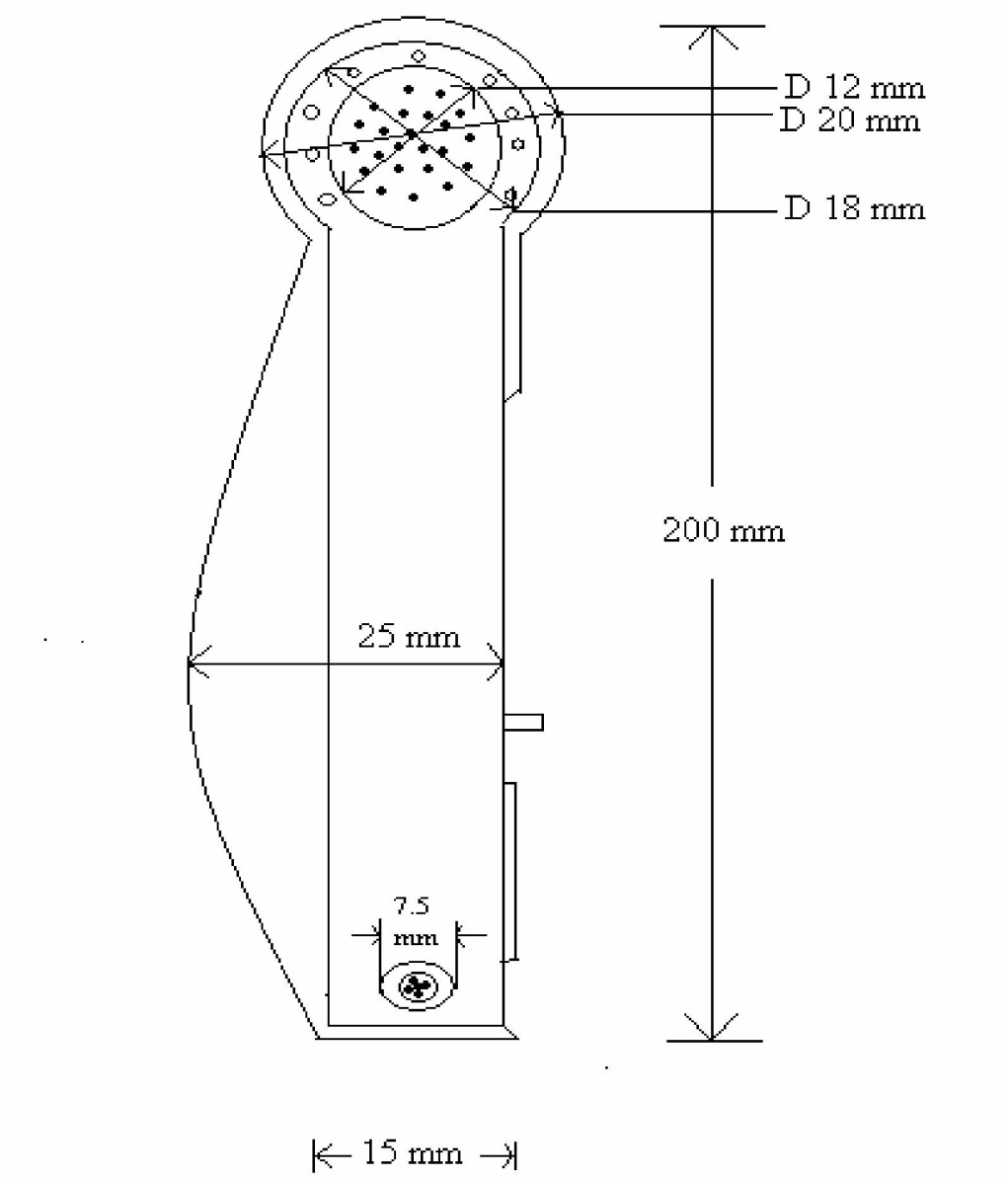


Fig. 9.2: Top view

Specification of motor DC 5000-7000 rpm power consumption around 2 watts

Specification of battery 9v dc battery

Push type on/off switch

Rotating brush head diameter 12 mm

Fixed brush head diameter 7.5 mm

Chapter 10

RESULTS AND DISCUSSION

10. Result and Discussion.

The most efficient system is as shown in the figure above. Based on market analysis, morphological analysis of the designs designed and finally arriving at the result, we have with us a device that suits our requirement. This device runs on a motor which consumes around 2W power and rotates at 7000-8000rpm. It uses a 9V battery and has a push type on/off switch. It has been given a decent aesthetic look, which would be attractive enough for marketing. The bristles are soft, so as to prevent from injuring the gums rather than cleaning it. This is the most efficient system. It is also the most costly system. It is also the most expensive one. Here both the brush heads rotate on both ends, finishing the job with good efficiency as required.

Further work on this design can be made in certain areas to increase its efficiency even more than what we get here. The motor speed can be increased to provide more effective cleaning. The anti-germinant can be chosen to include more qualities as in to act as a mouth freshner along with cleaning. The power source used now is a disposable 9V battery, it can be replaced to include a rechargeable battery, thereby reducing cost. The design can also be further improved to make it more compact.

Conclusion.

Among the various alternatives we have proposed for cleaning and anti-germinating the teeth the design shown is the most effective. The system developed is easy to use, efficient and refilled with anti-germinant easily. It is also economical. The design also provides further scope for work on it.

References

[1]www.animated-teeth.com

[2]www.qualitydentistry.com

[3]www.healthyteeth.org

[4] Kyle W.Sembera, ”Evolution and Analysis of Toothbrush” –Lamar University, Beaumont, Texas, USA., on www.asme.org

[5]www.dentalairforce.com

[6]en.wikipedia.org

[7]www.loc.gov/rr/scitech/

[8]www.kidshealth.org