May 29, 1973 J. J. DUGGAN 3,736,243

CORROSION PROTECTED RAZOR BLADE

Filed May 18, 1971

Fig. 2.

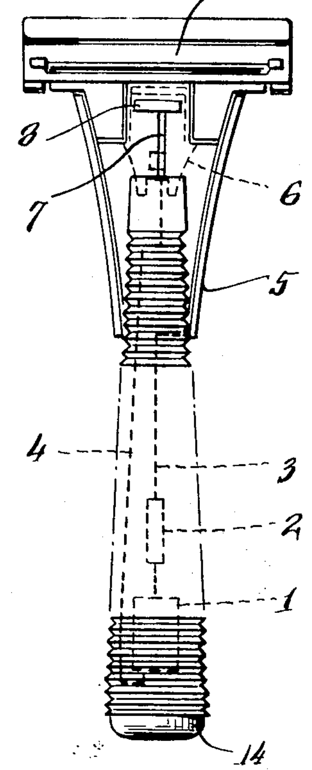


Fig. 1.

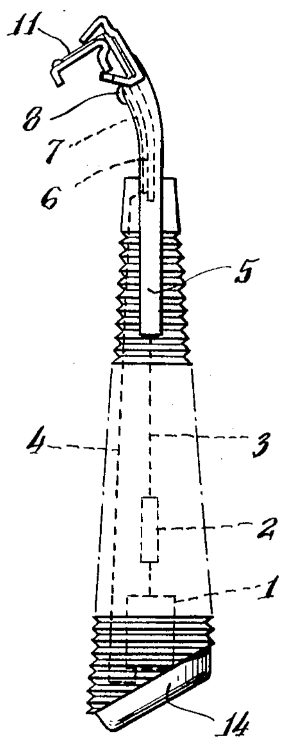


Fig. 3.

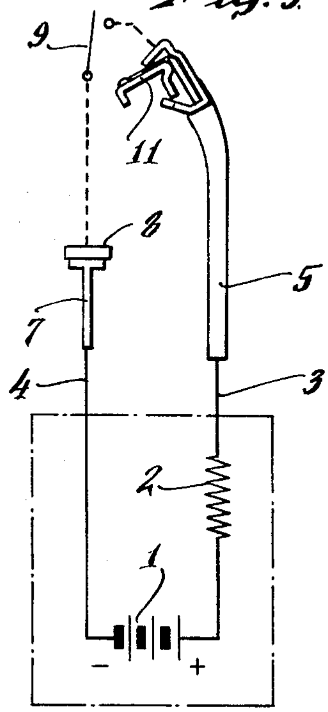
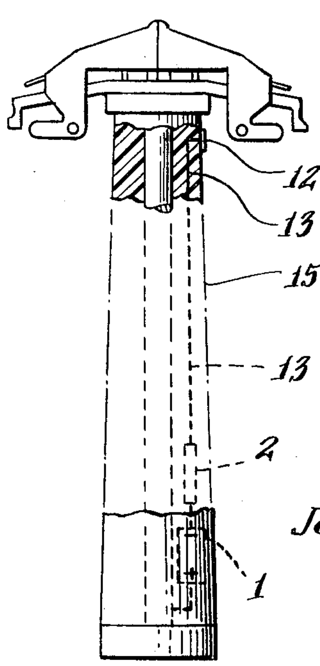


Fig. 5.



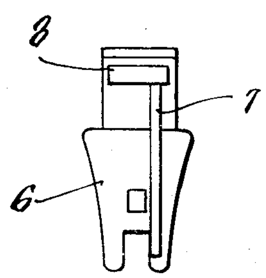


Fig. 4.

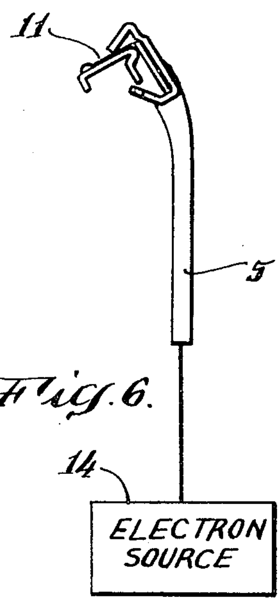


Fig. 6.

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3,736,243

Patented May 29, 1973

3,736,243

CORROSION PROTECTED RAZOR BLADE

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Filed May 18, 1971, Ser. No. 144,511
Int. Cl. C23f *13/00*
U.S. Cl. 204—196 3 Claims

ABSTRACT OF THE DISCLOSURE

A razor blade and holder combination is protected from corrosion by the application of appropriate electrical potential. The electrical circuit comprises a battery connected through a resistor for determining the desired current to the frame of the razor. A second connection is made to a separate electrode placed near the blade seat of the razor. The circuit is rendered operable by the action of the electrolyte solution normally present during use of the razor-blade combination.

BACKGROUND OF THE INVENTION

This invention is generally directed to the corrosion protection of shaving razors and more particularly directed to the appropriate application of electrical potentials to the razor to render such device substantially non-corrosive.

Realizing that razor blades and the holder devices associated therewith are generally formed from ferrous metals or at the very least corrosion-susceptible metals and that these devices are normally used in an extremely harsh environment of corrosive electrolyte solutions, the importance of corrosion protection to the razor blade industry becomes obvious. Throughout the evolutionary history of the razor blade art, there has always been associated with razor blades the fact of their limited useful existence due to corrosion attack. The first major successful step made in the direction of limiting blade corrosion comprised the use of high chromium content stainless steels in place of the high carbon content steels previously used in the razor blade industry. This change in material usage points out the great significance of corrosion to the ultimate life of the razor blade edge. Even though carbon steels provided a harder and, therefore, finer shaving edge, decision was made to go to a stainless steel material which is inherently softer and, therefore, incapable of providing the same hard and fine edge but which gives in the overall a much improved shave due to the greatly increased life of the shaving edge.

The next really significant step in the improvement of razor blades which provided corrosion protection as well as other significant improvements involved the sputter deposition of noble materials onto the surfaces comprising or making up the blade edge apex. The application of chromium or chromium alloy materials to the blade edges provided a corrosion resistant edge which in many instances increased the useful life of a razor blade by a factor of two and in some cases as high as a factor of three. The significance of this improvement can be appreciated by the simple fact that the entire blade industry has followed the lead of the innovator of this sputter deposition method and product and now it can be safely said that all razor blades on the market today, with the exception of a very small and limited percentage, have chromium or chromium alloy coated edges. Even with this greatly improved shaving blade, corrosion still is the single major factor involved with breakdown of the blade edge and concomitantly the shaving comfort of the blade itself. Of course, in addition to these radical improvements in corrosion resistance of the blade materials themselves, there have also been efforts employing ancillary devices and

materials directed toward the extrinsic improvement of corrosion protection. Chiefly, these efforts have involved the employment of protective greases and oil coatings to the surfaces of the blades, thereby insulating the blade edges from the corrosive attack of the electrolytes normally experienced in use. Obviously, however, once the blade edge has been exposed to a shaving experience, such protective greases and coatings are wiped away at least to some degree and, therefore, the protection provided by them is a limited one. Other devices employed constitute anodic or sacrificial anodes placed in contact with the blade on the razor blade holder frame. Since corrosion of the type associated with razor blades chiefly comprises the destruction or deterioration of material due to electrolytic reaction and oxidation at the surface of the material, the providing of an electrode consisting of a material having less corrosion resistance or a lower anodic potential forces the oxidation process or the removal of electrons to take place at this electrode rather than the blade with which the sacrificial anode is associated. While this method of corrosion protection is at least partially effective, it can be readily appreciated that the use of sacrificial anodes is questionable both from a cosmetic and structural point of view and as a practical matter the protection provided by such sacrificial anode does not seem to greatly increase the usable life of the blade. In this context, it may be significant to note that substantial amounts of hydrogen may be released at the anodic electrode, which hydrogen may have an embrittling effect upon the steel razor blade. With these attempts at corrosion protection of razor blades in mind and the continuing effort of the blade industry directed toward this same goal, it is apparent that any improvement in the corrosion protection of razor blades is an event of significance to the industry and may provide both economic and functional advantages.

It is, therefore, an object of this invention to provide an improved razor and blade combination. It is another object of this invention to provide a corrosion resistant razor and blade. It is yet another object of this invention to provide a method for protecting razors and razor blades from electrolytic corrosion.

SUMMARY OF INVENTION

In accordance with this invention, there is provided a corrosion protected razor and blade combination. The blade normally fabricated of corrosion-susceptible material is fixed in an appropriate holder providing an appropriate blade shaving position. A source of electrical energy of predetermined potential is then applied to the blade, which potential minimizes the corrosion susceptibility of the material.

There is also provided in accordance with this invention a method for protecting razor blades from corrosion. This method is provided by applying to the razor blade electrical energy of appropriate potential and polarity so as to render the blade substantially resistant to the corrosive action of its environment. In practicing this novel method, it has been found by empirical determination that the application of either positive or negative potentials to the blade edges of varying magnitude decreases the corrosion susceptibility of the blade material to a material extent.

The foregoing summary of invention as well as other objects and advantages will be made apparent upon a study of the following drawings and the detailed decription of the preferred and exemplary embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a single-edge type razor and blade combination showing a schematic outline form the appropriate electrical circuit configurations providing corrosion protection.

FIG. 2 is a front elevation view of the razor of FIG. 1 showing the electrical circuitry in outline schematic form.

FIG. 3 is a functional schematic of the razor and blade combination with its associated corrosion protection circuitry; portions of the razor to which electrical connections are made are shown in outline form.

FIG. 4 is a detail front elevational view of a portion of the razor of FIG. 1 to which a corrosion protection electrode is mounted.

FIG. 5 is a side view of a double-edge type razor and blade combination showing in outline form the electrical circuitry associated with providing corrosion protection.

FIG. 6 is a functional pictorial representation showing the essential requirements for electrical corrosion protection as applied to a razor-blade combination.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed description of the preferred embodiments when considered with the detailed drawings previously described will render clear the essential features and operational parameters of the applicant's novel concept. Conventional mechanical and electrical symbology are used throughout the detailed description and the drawings and like members are indicated by the same number throughout the various figures presented. It is noted that the description as well as the drawings are illustrative of the invention and are not to be considered delimiting of its scope.

FIG. 1 shows in typical oultine a single-edge type razor-blade combination. A handle **14** is rigidly connected to a metallic razor frame **5** to which razor frame **5** a blade or cutting edge **11** is fixedly clamped in a proper shaving position, i.e., the blade edge is oriented with respect to the frame so as to provide an appropriate shaving angle and edge exposure when placed in a shaving aspect. Normally the handle **14** comprises a plastic material while the frame **5** consists of a brass or other relatively soft material which is finally coated with an electroless nickel or other harder surfacing material. The blade **11**, as previously indicated, essentially and substantially is made of a ferrous material, desirably of a high chromium content stainless steel with a sputter deposited edge of chromium or chromium alloy, thereby providing maximum intrinsic corrosion protection to the razor blade itself.

The source of electrical energy and the circuit for conducting such energy to the razor frame **5** and blade **11** are shown in outline form within the body of the handle **14**. A battery **1** is connected with the appropriate potential through a substantially resistive element **2** by means of an electrical conductor which in turn is brought to the razor frame **5** by another conductor **3**. The opposite output terminal of the battery **1** is then conveyed through another electrical conductor **4** to an electrode **8** mounted on a leaf spring member **6** associatively connected with the razor frame **5** to apply a bias force for fixedly holding the blade in its proper aligned position. A connective member **7** establishes conduction between the electrode **8** and the conductor **4**. The conductor **4**, conductor **3**, resistor **2** and battery **1** are all potted or completsly sealed within the plastic handle **14**. Connections to the frame **5** and the connective member **7** are also made within the body of the handle **14**, thereby providing maximum protection to the electrical connections which must be made and reliably maintained throughout the functional life of the device. Connections to the frame **5** and the connective member **7** may be made by welding or soldering or by merely a pressure connection, as for example crimping, if the desired crimping forces can be maintained and applied. Normally, the electrode **8** and the connecting member **7** are selected from the material having a higher cathodic potential or galvanic potential than the blade steel and the razor frame **5** and it is advisable that such be essentially a noble material such as platinum so that such electrode **8** does not enter into the chemical reaction of corrosion or corrosion protection which occurs when in an electrolyte environment.

FIG. 2, as indicated previously, is a front elevational view of the same razor and blade combination depicted in FIG. 1. It more clearly depicts the functional location of the electrode **8** with respect to the razor blade **11** when fixedly mounted to the razor frame **5**. It is important to note that the electrode **8** is advisedly placed as close as possible to the razor blade **11** so as to ensure continuing operability of the corrosion protection circuit when the blade **11** is subjected to a harsh hydrous electrolytic solution. To state more clearly, as long as the razor blade **11** is wet, the electrode **8** should be in close proximity to the blade **11** i.e. sufficiently close in location to the blade **11** to have such electrolytic solution provide a conductive path therebetween; failure to place the electrode **8** in a proper location might cause a premature breaking of the electrical connection between the electrode **8** and the blade **11** necessary to the continued application of corrosion protection. FIG. 4 more clearly demonstrates the location of the electrode **8** and the connecting member **7** on the leaf spring **6** associated with the razor frame **5**. This same leaf spring is indicated in outline form in FIG. 2 and serves as a convenient place for the placement of the electrode **8**.

With the structural makeup of the razor as heretofore described, the operational requirements of the invention may now be considered. The electrochemical nature of corrosion may be illustrated by consideration of the corrosive attack of acids on metals. Essentially, the corrosion process or oxidation process involved is the removal of electrons from the metal, thereby forming metallic ions which then enter into the electrolyte solution. Thusly, an oxidation or anodic reaction is indicated by a decrease in valence or, conversely, a production of electrons. The released electrons then, of course, enter into another partial simultaneous reaction which constitutes a reduction or cathodic reaction yielding reaction products. It is imporant to note that during metal corrosion the rate of oxidation must equal the rate of reduction, i.e., electrons produced must equal electrons consumed. If such were not the case, the metal would spontaneously become electrically charged, which, in view of the law of conservation of charge, is clearly impossible. In normal acidic reactions, hydrogen is released at the cathode anode. This mechanism of corrosion immediately suggests one method for reducing the rate of corrosion. If electrons are supplied to the metal undergoing attack, then the reaction process of oxidation and reduction will not involve the taking of electrons from the metal but rather from the external energy source supplying electrons. This form of corrosion protection is illustrated in FIG. 6, which simply shows a razor frame **5**-blade **11** combination which is connected to an electron source **14**. In considering this approach as presented in FIG. 6, it must, of course, be realized that a complete circuit must be provided from the electron source **14** to the razor **5**-blade **11** combination, for without such complete circuit there would be no driving force available for supplying electrons. This factor goes back to our previous statement concerning the rate of oxidation equaling the rate of reduction and therefore no spontaneous charging of the corroding structure. In the state of the art today, this mode of corrosion protection is known as cathodic protection and is frequently used for the reduction of the corrosion process, particularly with respect to structures buried beneath the ground which are subject to wet or hydrous conditions. Relating back to our discussion of the prior art given at the outset of this specification, it can be realized that the use of sacrificial anodes is entirely analogous to the cathodic protection provided by an external source of electrons. If a more corrosive anode is placed in close position to the metallic object for which protection is desired, such anode forming part of a complete electrical circuit, it can be realized that this same corrosion process releases electrons to the member to be protected, thus reducing the corrosion process in a similar manner.

Another form of corrosion protection is provided by a phenomenon called "passivity." Many structural metals used today, fortunately including iron, chrome and nickel, demonstrate this phenomenon which apparently spontaneously provides corrosion protection to the metal undergoing attack. This phenomenon, as well as other mechanics and hypotheses of corrosion, are broadly discussed and explained in the text "Corrosion Engineering" by Mars G. Fontana and Norbert D. Greene, published 1967, McGraw-Hill, Inc. In this work, the authors define in a limited manner the characteristics of both cathodic protection and passivity. "Passivity" is quantitatively described by considering the action of a variable strength oxidizing agent on a metal displaying a typical passivity reaction.

As the oxidizing power or potential of the solution is increased by adding oxygen or ferric ions, the corrosion rate of the metal will increase rapidly. This increase in rate is exponential and yields a straight line when plotted on a semi-logarithmic scale. This area of behavior of the metal is known as its active region and the rapid increase in corrosion rate continues to a certain point inherent in the metal under inspection. At this point, the metal enters a passive region as the oxidizing power of the solution is further increased. Effectively a curve on the same semi-logarithmic basis folds back on itself indicating a rapid decrease in corrosion rate as the oxidizing power of the solution is further increased; ultimately it reaches a stable region where further increases in oxidizing power cause no additional increase in corrosion rate of the metal. At a second point characteristic of the metal, it enters into a transpassive region where, with increasing oxidizing power of the solution, the corrosion rate again rapidly increases approximately at a rate equal to that originally experienced in the active region of the metal. Of course, the area of extreme interest to those involved with corrosion protection of metal is the passive region, where, with increasing oxidizing power of the solution, no increase in corrosion is experienced and, in point of fact, it is reduced to an extremely low level. Actual empirical work has demonstrated that when entering into a passive state the metal experiences a reduction in corrosion between 10^{+3} and 10^{+6}, a phenomenal reduction indeed. To the present time, the nature of this metallic passivity has withstood exact analysis. However, it is hypothesized that a film approximately 30 angstroms or less in thickness containing considerable water hydration forms over the metal surface, which film is extremely corrosion resistant. Despite a lack of knowledge of the exact processes involved in the passivity phenomenon, this phenomenon has found wide engineering use in the protection of metals.

In application of corrosion protection to razors and blades in combination, it has been found that the passivity phenomenon provides the most useful and more easily applied corrosion protection process. This application of passivity to razors and blades is extremely fortunate when considering the extremely high reduction in corrosion which may be thereby obtained. As previously indicated, reductions in corrosion between one thousand and one million may be anticipated. In FIG. 3, a battery **1** is shown as applying a positive or passivating potential to the combined razor frame **5** and blade **11**. This potential is brought through a resistor **2** and a conductor **3** to the razor frame **5**. The negative terminal is brought through a conductor **4** to the electrode **8**, which, as previously indicated, is connected or mounted as close to the blade **11** as possible. A switch **9** is shown in phantom outline to demonstrate the action of the electrolyte on the circuit. When the razor is involved in the shaving process, it of course is exposed to a water-salt solution, which solution acts as a switch closing the circuit between the electrode **8** and the razor frame **5**-blade **11** combination. In view of the theory of corrosion without considering the phenomenon of passivity, such an electrical circuit would cause an increasing oxidation rate resulting in a more rapid corrosion and deterioration of the blade **11**. However, when considering the passivity phenomenon, it can be appreciated that with appropriate selection of electrical potential and circuit parameters the frame **5**-blade **11** combination may be driven to a potential level within the passive range of the structure, thusly reducing corrosion to a significant extent. In terms of actual application, it has been found that the use of an approximately 1 v. battery **1** connected through a 10 megohm resistor **2** establishes an apparently passive state for both the razor frame **5** and the blade **11**. These parameters were selected on a purely empirical basis but were found to provide satisfactory corrosion protection for a number of different razors and blades selected on a random basis. In each instance, the razor frame **5** consisted of a brass base clad with an electroless nickel coating while the blade itself comprised a high chromium content stainless steel with a sputtered chromium coating covering the final edge. All razors to which this circuit was applied displayed no corrosion for varying lengths or periods of time. A single razor and blade combination has been exposed to corrosive conditions for a period in excess of seven months without displaying any noticeable corrosion deterioration. In all instances, the razors and blades have been exposed to a typical salt solution normally experienced during shaving. Control razors and blades subjected to the same salt solution without the benefit of the corrosion protection circuit all corroded to extreme extents in less than a 24-hour period. The test razors and blades were continually taken from the solution and dried to closely approximate the environment normally experienced in use of the products. Appreciating the value of the selected resistor, i.e., 10 megohms, it can be seen that an extremely long life for this corrosion protection device may be expected, providing a suitable battery is utilized.

In the practice of this novel method of corrosion protection, it must be appreciated that the materials from which the razors and blades are fabricated as well as the inherent potential of these materials may change from time to time and indeed vary from one manufacturing lot to the next. In view of this, although analytical methods can be used for the selection of circuit components and parameters, it is thought most applicable that the necessary protection circuitry be selected on an empirical basis. Wider experience and statistical data may prove that a wide range of circuit values may be applicable to the practice of this invention or indeed it may be demonstrated that closer control of the basic materials of construction may be required to produce the desired level of corrosion protection. It is obvious from the foregoing analysis of corrosion that a failure to properly place the blade potential in the passive region may result in a rapid deterioration of the metallic structure and, in point of fact, a more rapid deterioration than might be normally experienced without such corrosion protection being attempted. FIG. 5 of this application shows the application of corrosion protection devices conforming to the teachings of this invention to a double-edge razor. Similar to the single-edge type razor, a battery **1** is connected to the metallic seat and frame of the razor. The negative potential is brought through a resistor **2**, through a conductor **13** to an electrode **12**. This electrode **12** would comprise a ring device mounted on the periphery of the razor handle **15** as closely mounted to the seat of the razor blade as possible. The use of a plastic material for the handle member **15** would permit encapsulation of the circuit components within the handle **15** and further provide an insulative mounting for the protective electrode **12**. It is important to note at this point that the protective electrode **8** and the connective member **7** mounted on the leaf spring **6** of the single-edge type razor would also require an insulative barrier between the electrode

8 and member 7 and the leaf spring 6. This may be provided by a mica strip or other suitable insulative material which, in combination with the circuit members, may be cemented or otherwise attached to the leaf spring 6.

It is the applicant's belief the theory herein presented with respect to both the corrosion phenomenon as well as the corrosion retardation phenomenon is well based and correct. However, since such explanations are intended as an aid to understanding of the invention and not necessary to its practices, it is intended that these theories be considered possible explanations of the processes involved therein and that, should they prove in variance with actual fact, the merit and scope of the applicant's invention be unaffected. Further, it is pointed out that the embodiments of the invention are merely presented as illustrative of the novel concept and are in no way delimiting of the scope of the invention. Thusly, all those modifications and alterations obvious or apparent to one skilled in the art are considered to be within the scope and ambit of this invention.

What is claimed is:

1. In a safety razor system comprising a handle, a metallic frame, a metallic razor blade, and means for supporting said blade in abutting contact with said frame, the combination comprising:

a DC power source supported by said handle and including a positive terminal and a negative terminal, means for electrically connecting said positive terminal to said frame,

an electrode,

means for supporting said electrode in close proximity to said blade and for electrically insulating said electrode from said blade and said frame,

means for electrically connecting said negative terminal to said electrode, and

resistance means serially connected in circuit with said DC power source, said electrode and said frame for limiting current flow,

said DC power source and said resistance means having electrical values for maintaining said blade in a passive state when at least said blade and said electrode are immersed in a corrosive electrolytic solution.

2. The system of claim **1** wherein said power source has approximately 1-volt output potential, and wherein said resistance means is approximately 10 megohms.

3. The system of claim **1** wherein said frame and said blade are composed of materials selected from a group consisting of iron, steel, nickel and chromium.

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U.S. Cl. X.R.

30—32; 204—147