Nov. 28, 1961 R. P. SEELIG ET AL 3,010,856

METHOD OF MAKING AN ABRADANT ELEMENT FOR SPARK GENERATING DEVICE

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FIG. 1.

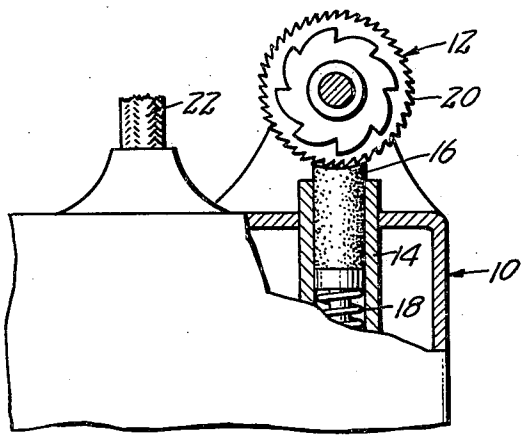


FIG. 2.

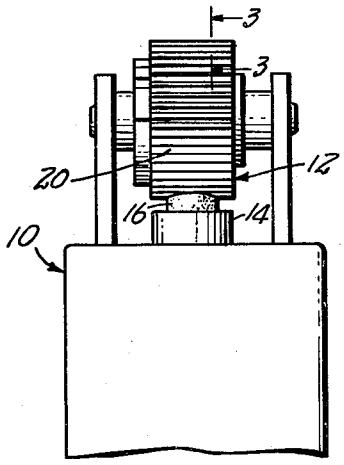


FIG. 3.

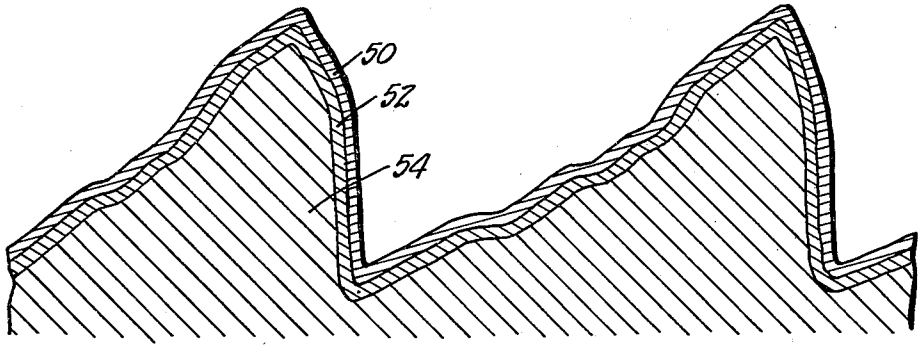
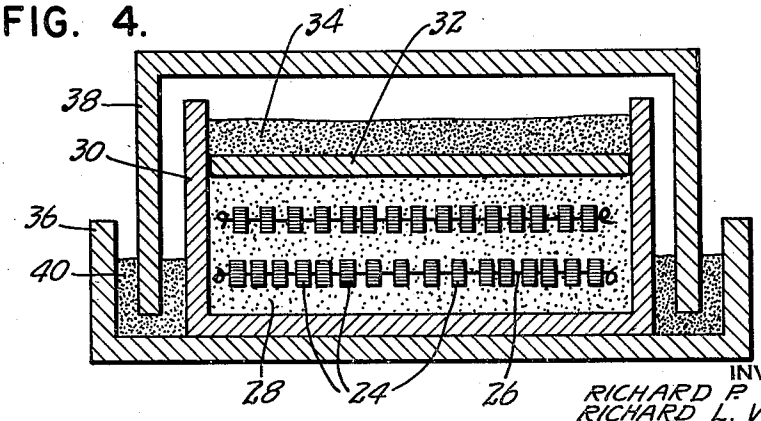


FIG. 4.



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This invention relates to mechanical spark-generating devices. Such devices commonly comprise a ferrous metal abradant element having a roughened surface and an element made of a pyrophoric material, commonly called a "flint." The elements are rubbed against one another to cause the rough surface of the abradant element to remove from the pyrophoric element particles of the pyrophoric material that ignite spontaneously in air to form a spark which can in turn be used to ignite a gaseous or liquid fuel.

A typical example of such a spark-generating device is the conventional cigarette lighter wherein a ferrous metal spark wheel having a serrated peripheral surface is positioned in contact with one end of a tubular pyrophoric element, and the pyrophoric element is held against the periphery of the spark wheel under light spring pressure. In use the spark wheel is either manually or mechanically rotated to produce, by its abrasive action on the pyrophoric element, a spark for igniting the fuel of a fuel-saturated wick located adjacent to the spark generating device.

Another example of such a spark-generating device is the gas lighter which at one time was widely used for igniting the gas of gas-burning domestic cooking stoves and is still extensively used as a gas igniter. Such gas lighters comprise an abradant plate or cylinder against which a spring-mounted pyrophoric element bears in such manner that the pyrophoric element can be drawn across the abradant plate to produce the desired gas-igniting spark.

The present invention is particularly concerned with the abradant element of such a spark-generating device and it is a general object of the invention to provide an abradant element of this character which has a longer useful life and greater reliability than the abradant elements heretofore available for use in spark-generating devices. For convenience the invention will be described herein as applied to the spark wheel of a cigarette lighter, although as the description proceeds it will be apparent that the invention can equally well be embodied in abradant elements having other geometrical configurations and used for other purposes.

Known types of ferrous metal spark wheels with abradant teeth or ridges formed in the periphery thereof have heretofore been made from high carbon steels, i.e. steels having a carbon content of 0.95 to 1.25% by weight carbon, as well as from low carbon steels with subsequent surface hardening of the abradant surface of the wheel by a variety of known techniques. In spite of these prior efforts to produce a durable product, the spark wheels previously available have had a relatively limited useful life. Rotation of such a spark wheel against the pyrophoric element tends to dull, bend or otherwise deform the cutting or abrading edges or ridges of the periphery of the wheel, thus effectively destroying the utility of the lighter in which the wheel is mounted after say 5,000–10,000 operations. Our studies indicate that the limited useful life of such spark wheels is due in large measure to the fact that the materials used in their manufacture, while relatively hard at atmospheric temperatures, have not had a sufficiently high softening temperature. In operation, the abradant surface of the wheel is subjected to localized heat and pressure which soften

the material of the cutting edges or ridges, thus causing them to be bent, blunted or otherwise deformed in such manner that they function inefficiently or ineffectively.

It is accordingly an object of the present invention to provide an abradant element for a spark-generating device having improved durability. It is another object of the invention to provide an abradant element such as a spark wheel having an abradant surface which is harder and retains its hardness at higher temperatures than the abradant surfaces of abradant elements heretofore used. It is still another object of the invention to provide an improved method of making such an abradant element. Other objects of the invention will be in part obvious and in part pointed out hereafter.

The objects of the invention can be achieved in general by forming on a spark wheel of conventional configuration a hardened surface layer essentially composed of chromium carbide. It has been found that when such a chromium carbide layer is properly formed at the abradant surface of the spark wheel as described more particularly hereafter a product having greatly improved durability is achieved. The atmospheric temperature hardness is relatively high, i.e. of the order of 1800 to 2200 on the Vickers scale, and no significant softening of the surface material occurs at temperatures as high as 1800° to 2000° F. Moreover the hardness of the material is such that even when the abradant projections on the periphery of the wheel are overstressed, the wheel remains functionally effective. Thus if the localized pressure on a peripheral ridge or tooth of the wheel exceeds that which the ridge can sustain, the ridge does not bend or deform plasticly but rather a small piece breaks off along a jagged fracture line to leave a surface that is still abradant. It has been found that the spark wheels embodying the present invention have a useful life, in terms of the number of spark-generating operations they can perform before becoming ineffective, of the order of four times that of the spark wheels previously available.

In order to point out more fully the nature of the present invention reference will now be made to the accompanying drawing which illustrates a spark wheel embodying the present invention and an apparatus which is useful in carrying out the method of the invention.

In the drawings:

FIGURE 1 is a side elevation, partly broken away, of the upper portion of a cigarette lighter illustrating the spark wheel, flint and wick assembly thereof,

FIGURE 2 is a right-end view of the structure of FIGURE 1,

FIGURE 3 is a greatly enlarged section through the abradant surface of the spark wheel taken on the line 3—3 of FIGURE 2 and illustrating the hardened layer at the operating surface of the spark wheel, and

FIGURE 4 is a vertical longitudinal section through a retort adapted to be used in carrying out certain steps of the method of the invention.

Referring to the drawing and more particularly to FIGURES 1 and 2, a portion of a conventional cigarette lighter is illustrated therein comprising a body or fuel receptacle **10** having a spark wheel **12** rotatably mounted thereon. Formed in the body **10** there is a tube **14** in which a rod-shaped pyrophoric element such as the conventional "flint" **16** is slidable. The element **16** is urged by a spring **18** toward the abradant surface **20** of spark wheel **12**. Surface **20** is provided with ridges, teeth or other serrations of any suitable and well-known type. A fuel-saturated wick **22** is positioned near the spark wheel. Rotation of the spark wheel **12** in contact with element **16** generates a spark which ignites the fuel-saturated wick in known manner.

In producing spark wheels of the type disclosed and

claimed herein, spark wheel blanks having the desired ridges or other serrations in the periphery thereof are formed from a suitable ferrous metal core which may be either a high carbon or low carbon steel. Since the desired serrations at the periphery of the blank can be more readily and economically formed if a low carbon steel is used, we prefer to use a relatively mild steel having a carbon content of less than say 0.7% by weight for this purpose.

In accordance with a preferred embodiment of the method of the present invention, ferrous spark wheel blanks made of such a mild steel are first subjected to a carburizing treatment to increase substantially the carbon content at the surface of the wheel. Carburization of the spark wheel blanks is effected by embedding them in a pack composed of a suitable comminuted carburizing medium in a container and introducing the container into a furnace which is maintained at a temperature of 1700° F. to 1900° F. for a period of 4 to 10 hours. Any of various commercially available carburizing media may be used. Such carburizing media commonly comprise a mixture of carbon and various carbonates. The time and temperature may be varied according to the degree of carburization desired. In general the carburizing treatment is preferably carried out in such manner that the carbon content of the surface of the spark wheel blank is increased to say 0.8% to 3% by weight to a depth of at least 1/16". Carburization of the spark wheels may also be effected by gas carburization.

After carburization the spark wheel blanks are removed from the carburizing medium and then subjected to a chromizing treatment. Chromizing is desirably effected by embedding the blanks in a suitable chromizing pack and heating them therein to an elevated temperature. The chromizing pack may comprise for example a finely divided mixture of ferrochrome and a filler such as kaolin, either calcined or uncalcined, or alumina, together with a small amount of ammonium iodide. Heating of the spark wheel blanks in the chromizing pack is carried out at a temperature and for a period of time sufficient to provide a hardened chromium carbide casing at least 0.00075" thick at the surface of the wheel. The desired chromium-containing hardened casing can be achieved by using essentially the same heating schedule as in the carburizing step, i.e. 1700° to 1900° F. for a period of 4 to 10 hours.

The nature of the hardened casing thus obtained is illustrated in FIGURE 3 of the drawings which is a section through two of the teeth or ridges of the abradant surface **20** of spark wheel **12**. Referring to FIGURE 3, it will be noted that the hardened casing is essentially bi-laminar and comprises the outer layer **50** and inner layer **52** at the surface of the ferrous metal spark wheel core **54**. The outer layer **50** is relatively high in chromium content and is composed almost entirely of chromium carbide having substantially the formula Cr_4C. The inner layer **52** contains a certain amount of iron in combination with chromium and carbon and appears to be essentially a mixture of chromium carbide having substantially the formula Cr_7C_3 and an iron chromium carbide, probably $(CrFe)_7C_3$. As indicated above the outer chromium carbide layer **50** has a Vickers hardness of about 1800 to 2200.

In order to illustrate further the method of the present invention the following specific example is given of a preferred procedure for making spark wheels embodying the invention. Referring particularly to FIGURE 4 of the drawings, the spark wheel blanks **24**, made of steel having less than 0.7% carbon, are strung on a rod or wire **26** and packed in the comminuted carburizing medium **28**, which may be the medium sold commercially under the trade name "Pearlite," in the container **30**.

After the spark wheel blanks **24** have been packed in the carburizing medium in the container **30** a loosely fitting cover **32** is placed on top of the pack and a layer of a suitable sealing medium **34** in then spread on top of cover **32**. The sealing medium can be a finely divided silicate which softens to form a gas impervious seal at a temperature of the order of 1400° F. The container **30** is placed in a tray **36** and an outer cover **38** is then positioned over the container. As illustrated the side walls of outer cover **38** are positioned between container **30** and the walls of tray **36**. A sealing material **40** which may be the same as the sealing material **34** is positioned adjacent to the lower rim of cover **38** to provide a second seal.

The assembled tray and container are then introduced into a furnace in which they are heated to about 1900° F. for about 6 hours. During the early stages of the heating cycles gases are evolved from the carburizing material **28** that pass through the seals **34** and **40** to the atmosphere. These evolved gases sweep out any atmospheric oxygen that may have been retained in the pack **28**. As the temperature rises the seals **34** and **40** melt but still permit passage of gas therethrough. At the end of the heating cycle the tray **36** is removed from the furnace and allowed to cool. During cooling the seals **34** and **40** solidify to prevent atmospheric oxygen from entering the pack **28** and reaching the treated spark wheel blanks during the cooling period, thereby preventing oxidation of the surfaces of the blanks during this period. The average carbon content of the surface portion of the spark wheel blanks to a depth of 1/16" at the end of this carburizing treatment is about 1.5% by weight.

When the carburizing treatment has been completed the spark wheels are removed from the carburizing pack and then submitted to a chromizing treatment. The chromizing of the spark wheel blanks may be carried out in the same type of retort as that described above, but with a different pack composition. The chromizing pack of the present example comprises about 35% by weight of alumina, about 65% by weight of ferrochrome having a chromium content of about 65%, and about 0.25% of ammonium iodide. All components of the pack have a particle size less than 100 mesh. The retort containing the chromizing pack with the spark wheels embedded therein is heated at about 1880° F. for a period of 6 hours. As the pack is heated up the ammonium iodide decomposes to form ammonia and elemental iodine, and at a somewhat higher temperature the ammonia decomposes to form nitrogen and hydrogen. A portion of the generated gases flow out through the seals **34** and **40**, thereby sweeping out any atmospheric oxygen present in the pack. The hydrogen formed by decomposition of the ammonia provides a reducing atmosphere and reacts with any oxide coating that may be present on the spark wheels. As the temperature of the pack continues to rise, the iodine reacts with the chromium of the pack to form a volatile iodide from which chromium is deposited on the spark wheel surfaces. The deposited chromium diffuses into the spark wheel blanks to form the bi-laminar hardened casing described above.

At the end of the heating period the retort and pack are cooled and the spark wheels removed therefrom. The resulting spark wheels comprise a ferrous metal core having a serrated abradant peripheral surface provided with a bi-laminar hardened casing, the outer layer of which is a very hard coating of chromium carbide.

From the foregoing description it is apparent that the present invention provides an abradant element for a spark-generating device and a method of making the same that are capable of achieving the several objects set forth at the beginning of the present specification. The exceptionally hard chromium carbide coating substantially increases the useful life of the abradant element. Moreover the nature of the casing or coating is such that if the abradant serrations are over-stressed they break off to leave a jagged surface that is still abradant.

It is of course to be understood that the foregoing description is illustrative only and that numerous changes can be made in the materials, conditions and proportions

set forth without departing from the spirit of the invention as defined in the appended claims.

We claim:

1. The method of making an abradant element for a spark-generating device which comprises forming a ferrous metal blank having a serrated abradant surface having sharp points, carburizing said abradant surface to increase the carbon content of the portion of said blank adjacent to said surface, and thereafter pack chromizing said carburized abradant surface to form a hardened casing at said surface essentially composed of chromium carbide while maintaining the sharpness of said sharp points of said serrated surface.

2. The method of making a spark wheel adapted to be used in the spark-generating assembly of a cigarette lighter which comprises, forming from steel having a carbon content less than 0.7% by weight a cylindrical blank having a serrated abradant cylindrical surface with the outer edges of the serrations being sharp, carburizing said abradant surface to increase the carbon content of the peripheral area of said wheel to a depth of at least 1/16" to an average carbon content of 0.8% to 3% by weight, and thereafter pack chromizing said carburized surface of said wheel to provide a layer of chromium carbide at the abradant peripheral surface thereof having a thickness of at least 0.00075" while maintaining the sharpness of said sharp edges of said serrations.

3. The method of making a spark wheel adapted to be used in the spark-generating assembly of a cigarette lighter which comprises, forming from steel having a carbon content less than 0.7% by weight a spark wheel blank having a serrated abradant peripheral surface, embedding said blank in a comminuted carburizing medium, heating the blank in said carburizing medium to a temperature of 1700° to 1900° F. for a period of 4 to 10 hours to increase the carbon content of the peripheral portion of said blank to 0.8% to 3% by weight to a depth of at least 1/16", removing said spark wheel blank from said carburizing medium and embedding it in a chromizing pack essentially composed of a mixture of finely divided ferrochrome and alumina and a small amount of ammonium iodide, and heating said spark wheel blank in said chromizing pack to a temperature of 1700° to 1900° F. for a period of four to ten hours to form at the peripheral portion thereof a hardened bi-laminar casing having a thickness of at least 0.00075" and composed largely of chromium carbide.

4. In a method for the manufacture of an article having a serrated surface, the steps which comprise forming from steel a blank of said article having said serrated surface, carburizing said serrated surface of said blank for the hardening and strengthening thereof, and thereafter chromizing said carburized surfaces of said steel blank by heating said blank embedded in a chromizing pack comprising a source of chromium and finely divided refractory filler and a source of volatile halogen for diffusion coating of said chromium into said carburized surface of said blank to form an outer diffusion coated layer comprising chromium carbide on said serrated surface of said article.

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