Nov. 24, 1959 E. W. MEYER, JR., ET AL 2,914,695

DEVICES FOR REGULATING ELECTRICAL DISCHARGES

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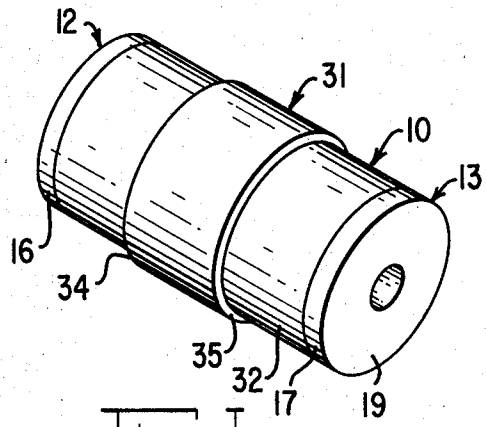


FIG. I

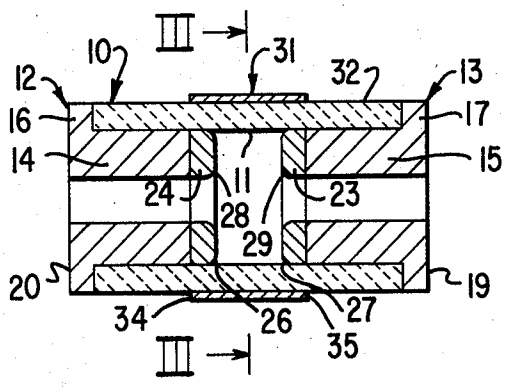


FIG. II

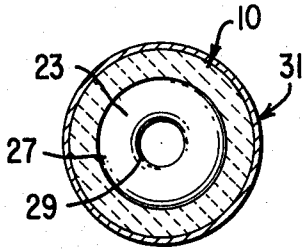


FIG. III

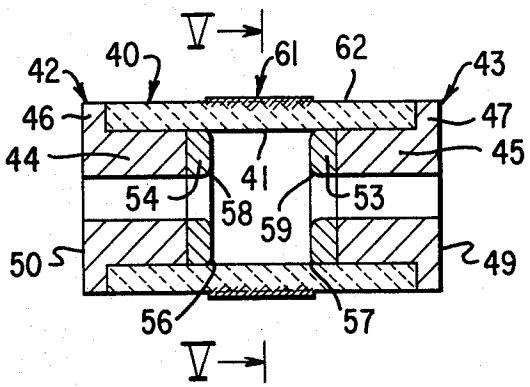


FIG. IV

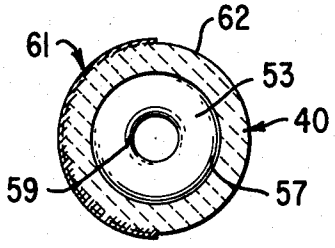


FIG. V

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DEVICES FOR REGULATING ELECTRICAL DISCHARGES

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7 Claims. (Cl. 313—325)

This invention relates to devices for regulating electrical discharges and more particularly to the method and means for decreasing and stabilizing the break-down potential required to produce a jump spark across a predetermined space, as well as for producing spark gaps or spark intensifiers adapted to operate consistently for prolonged periods at high sparking rates in excess of about 250 sparks per second.

The invention comprehends a method for regulating and securing rapid electrical discharges across spaced electrodes at a break-down voltage of low value which is predictable and consistent.

The invention comprises means located in predetermined position with respect to spaced electrodes in order to concentrate the established electrical field to provide a very stable spark gap in which successive electrical discharges with substantially no time lag are produced at consistently low voltage.

The invention contemplates a spark intensifier of extremely stable characteristics for operation at high sparking rates in ignition systems of variable speed engines. The term "spark intensifier" is herein used to designate a device which is used to provide an auxiliary spark gap in circuit with the firing gap of a spark plug for regulating the electrical discharge of the latter until the firing or secondary voltage of the ignition system has reached a potential such as to cause a spark to jump across the auxiliary gap, as well as the gap of the spark plug, although the spark plug may be fouled by carbon deposits or other foreign or deleterious matter.

The invention embraces a non-sealed spark gap for use with electrical ignition systems for internal combustion engines provided with a body having a dielectric constant higher than air located in close proximity to the electrodes, so that the established electrical field is concentrated to cause a rapid ionization of the air space between the electrodes whereby the non-sealed spark gap discharges consistently at a predetermined low break-down voltage not greatly affected by variations of atmospheric conditions.

The invention includes a spark gap having means for enhancing the rapid ionization of the space between the electrodes by utilizing a conducting member separated from the electrodes by a thin partition having a dielectric constant higher than air and wherein the conducting member is arranged to bridge the gap between the electrodes without having direct connection therewith so as to be in effect an "electrically floating" conducting member.

According to the foregoing summary of the invention indicating the general nature and substance, its main objective is to provide a device for regulating electrical discharges including means and their arrangement for decreasing and stabilizing the break-down potential required to produce a jump spark across a predetermined space whereby such device is very stable and operates satisfactorily for a long period of time at high sparking rates in excess of about 250 sparks per second.

Conventional spark gaps, as well as spark intensifiers,

have been entirely unsatisfactory for prolonged applications in electrical circuits where high sparking rates are required due to their lack of stability and exceedingly short life. The attainment of constant characteristics in a spark gap and the prolongation of its effective life when used at high sparking rates present many problems whose solutions require careful evaluation and effective regulation of many variable factors. This is particularly true in connection with non-sealed gaps, and heretofore, many attempts to solve these problems have been unsuccessful, so that spark gaps of the non-sealed type are commercially unavailable. Moreover these problems have not been successfully solved in connection with conventional spark gaps or intensifiers of the hermetically sealed type on account of the fact that these devices have undesirable high and inconsistent impulse ratio and surge spark over voltage, as well as a considerable time lag and short effective life, rendering the same ineffective and unsuitable for use in ignition systems of high compression multi-cylinder engines which are required to operate at high sparking rates in excess of about 250 sparks per second.

One of the main objects of the invention is to avoid the foregoing draw-backs and produces a very compact or minute spark gap or a spark intensifier of extremely stable characteristics and of long-lasting effective life at high sparking rates adapted for use in ignition systems of variable speed high compression multi-cylinder engines.

Another object of the invention is to provide a spark gap having dielectric and electrically floating conducting means whereby the electrical field, due to the application of a voltage to its spaced electrodes, is controlled and concentrated, causing rapid ionization to thereby furnish free electrons radiating into the space separating the electrodes to produce an electrical discharge at a consisent and predictable low voltage producing a simplified spark gap which has a very low impulse ratio and practically no time lag.

Another object of the invention is to provide a non-sealed gap in which its discharge characteristics are constantly maintained, so that operation effectiveness is not impaired when used at high sparking rates in excess of about 250 sparks per second.

Another object of the present invention is to provide a spark intensifier which will cause a fouled spark plug to fire at an electrical potential substantially lower than that required heretofore by conventional spark plug intensifiers, which is predictable and consistent, and wherein the stability of the spark intensifier is not impaired when used at the recurrent discharge rate in the high order that is required when the same is used in ignition systems of engines wherein, in actual practice, such rate is in excess of about 250 discharges per second.

Another object of the invention is to provide a spark gap in which a conducting metallic band is carried on the outside of a member including a section of minimum thickness consistent with its insulating strength and which has a dielectric constant higher than air contacting the electrodes and wherein said conducting band is dimensioned to extend the length of the gap separating the electrodes overlapping their firing tips, whereby rapid ionization of the space between the electrodes is consistently attained.

A further object of the invention is to provide a spark gap or spark intensifier of the non-sealed type of stable and long-lasting characteristics wherein the spaced electrodes are interconnected by an insulating spacer or body of high dielectric constant to provide a surface sparking gap and are devoid of sharp points or edges, thus eliminating objectionable electrode pitting which renders conventional devices ineffective after short operating periods.

A further object of the invention is to provide a very

compact spark gap of utmost simplicity which broadly includes three components: first, spaced electrodes having their discharge or vulnerable surfaces of high melting point metals, or of high erosion-resistant conducting materials without sharp edges; second, a body having a dielectric constant at least higher than air and of a very thin cross-section consistent with its insulating qualities intervening between the electrodes and in contact therewith to form, in effect, a surface sparking gap; and the third and last component, a conducting electrically floating member spaced or separated from the electrodes by said dielectric body and dimensioned to over extend or bridge the length of the said surface sparking gap. In carrying the invention to practice, as shown in the embodiment herein disclosed, and consistent with economical manufacture, the dielectric body constituting the second component also performs the function of a housing or main support for the other components of the spark gap.

Other objects and advantages of this invention relating to the arrangement, operation and function of the related elements of the structure, to various details of construction, to combinations of parts and to economies of manufacture, will be apparent to those skilled in the art upon consideration of the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Referring to the drawings:

Fig. I is an enlarged isometric view of a spark gap constructed in accordance with the principles of the present invention;

Fig. II is a longitudinal sectional view, on an enlarged scale, of the spark gap shown in Fig. I;

Fig. III is a cross-sectional view, on an enlarged scale, taken in line III—III of Fig. II looking in the direction of the arrows;

Fig. IV is an enlarged longitudinally sectional view of a spark intensifier constructed in accordance with the principles of this invention;

Fig. V is an enlarged cross-sectional view taken substantially in line V—V of Fig. IV looking in the direction of the arrows.

The present invention may be incorporated in any suitable type of device for regulating electrical discharges and, for practical application of its principles, the same is illustrated in the drawing as embodied in spark gaps and spark intensifiers of the types highly adaptable for use in ignition systems of variable speed, high compression, multi-cylinder engines. However, it is to be understood that the invention is not limited in its application to the particular forms shown but that it is contemplated that the principles of the invention may be used whenever the same may be found to be applicable.

Referring to the drawings, and particularly to Figs. I to III inclusive, the embodiment of the invention therein illustrated, by way of example, shows the dielectric component of the spark gap whose dielectric constant is higher than air, performing two functions, first, as the means for decreasing and making consistent the break-down potential required to produce a rapid jump spark across the electrodes, and second, as a support and housing for the other components of the spark gap. As particularly shown in Fig. II, the numeral **10** designates a rigid, perforated shell or hollow housing having an axial bore centrally located forming an open-ended tubular enclosure of comparatively thin wall section.

According to the principles of the invention, the housing **10** is made of a material having a dielectric constant at least higher than air and of suitable insulating characteristics to provide a surface or a spacer of minimum thin cross-section intervening between the discharge surfaces of the spaced electrodes. In carrying the invention to practice, it has been found advantageous to make or form the housing from suitable ceramic insulating materials, including porcelain whose dielectric constant is considerably higher than air, so that the housing walls are of a minimum cross-section consistent with its insulating qualities. The housing **10** is dimensioned and arranged to support the electrodes **12** and **13** by direct engagement therewith and maintain them apart in fixed position within its axial bore by having a close fit therewith, so that accurate spacing or a non-conducting gap of predetermined length is provided. In this embodiment of the invention, the inner surface of the tubular housing **10**, and particularly the thin section thereof intervening between the spaced electrodes **12** and **13**, operates to form, by intercommunication therewith, a surface sparking gap **11** bridging, in effect, the non-conducting gap.

Each of the electrodes **12** and **13** is, for ease of manufacture, shown as a duplicate composite structure which, in each case, is pierced at its central portion forming respectively tubular sections **14** and **15**. These tubular sections have, at their respective ends, enlarged heads **16** and **17** dimensioned to co-extend and be in alignment with the outer periphery of the tubular housing **10**, forming thereby external terminals or connecting plates **19** and **20** for the spaced electrodes. The inner end of the respective tubular sections **14** and **15** are capped by ring-like or annular members **23** and **24** which constitute the other component of the electrode structure and may be termed as its vulnerable end or discharge surface. The tubular sections **14** and **15** of the electrodes **12** and **13** are dimensioned to provide a relatively large mass and are preferably made of a base metal or material having good thermal and electrical conductivity not readily oxidizable by electrical discharges.

The vulnerable components **23** and **24** of the composite electrodes **12** and **13** are fixed or carried in direct electrical contact with the ends of the corresponding tubular sections **14** and **15** by having their rear surfaces brazed or welded thereto, and are shaped and dimensioned so that their surfaces are in intimate contact with the bore of the housing **10**. The annular members **23** and **24** are preferably formed and arranged, so that their discharge faces are uniplanar and rounded off at their outer periphery, as at **26** and **27** respectively, thus avoiding sharp edges or square corners adjacent to the surface gap **11**, thus providing co-planar flat sections spaced adjacent to each other in substantially parallel relation and have their ends adjacent to the central bore rounded off as at **28** and **29** respectively. The vulnerable sections **23** and **24** of the composite electrode structures are preferably made of good erosion-resistant, conducting materials, or of metals having a high melting point. In carrying the invention to practice, it has been found highly advantageous to form each one of the members **23** and **24** of either tungsten, molybdenum, tantalum, or alloys of such metals. However, it is contemplated that other materials having the characteristics before mentioned may be used.

In the form of the invention disclosed in Figs. I to III inclusive, the means to enhance the rapid ionization of the space between the electrodes for decreasing the time lag of the electrical discharge, as well as regulating and stabilizing the break-down voltage of the spark gap, are shown in the form of an electrically floating metallic band **31** surrounding or embracing the electrodes but not physically connected to either. The band **31** in the form shown is coaxial with the electrodes and is separated therefrom by being supported by the housing **10** by having direct engagement with its outer surface **32**. The band **31** is preferably made of a homogeneous conducting substance which is illustrated in the form of a flat metallic ring surrounding the electrodes and being dimensioned, so that its length is somewhat greater than the length of the space separating the electrodes, so that the outer ends **34** and **35** of the band **31** extend beyond a slight distance and thereby overlap a portion

of the area of members 23 and 24, as can be seen by a perusal of Fig. II.

The conducting member 31 which, in accordance with the principles of the invention in the form shown, depicts the means to reduce the impulse ratio of the spark gap and makes possible a fairly low and consistent potential to cause an electrical discharge is symmetrically placed to bridge the surface gap 11 with its outer ends 34 and 35 properly spaced from the enlarged sections 16 and 17 of the electrode structure so that flash-over will not occur or precede the electrical discharge between the discharge surfaces 23 and 24. In carrying the invention into practice, it has been found that the space separating the outer surfaces 34 and 35 of the conducting band with respect to the co-adjacent enlarged sections 16 and 17 of the electrodes should be at least more than one-half of the length of the space separating the discharge surfaces 23 and 24, in order to avoid flash-overs therebetween. It has been found by experience, based on comparative tests, that the co-axial separation or radial spacing of the electrical floating body 31 with respect to the electrode significantly affects its function as a controlling factor in reducing the impulse ratio of the spark gap and the consistency of its break-down voltage. In view of this fact, the walls of the housing 10 should be of a minimum cross-section consistent with the strength, as well as the insulating characteristics, of the dielectric material from which the same is made.

In Figs. IV and V, the invention is shown as embodied in a spark intensifier in which the three basic components of the spark gap of the invention are correlated in a manner very similar to the device previously described. The spark intensifier shown in Figs. IV and V comprises a tubular housing 40 of insulating material of high dielectric constant arranged to support electrodes 42 and 43 in spaced relation within its axial bore and having a close fit therewith. In this embodiment, the walls of the housing 40 are of very thin cross-section and, due to their interconnection with the electrodes, provide a dielectric spacer constituting a surface spark gap 41 bridging the space separating the electrodes.

The electrodes 42 and 43 of the spark intensifier are also shown in the form of a composite cylindrical structure of hollow configuration formed by tubular sections 44 and 45 located within the housing 40 and provided with enlarged end sections 46 and 47 respectively which project from each end of the housing with their lateral walls in alignment thus forming connecting plates or external terminals 49 and 50 for the spark intensifier. The inner ends of the tubular sections 44 and 45 are capped by hollow cylindrical members 53 and 54 which constitute the other components of the electrode structure and are the vulnerable ends or their discharge faces. The tubular sections 44 and 45 are dimensioned to provide a relatively large mass and are formed of suitable materials having good thermal and electrical conductivity, not readily oxidizable by electrical discharges. The members 53 and 54 are respectively secured to the ends of each one of the sections 44 and 45 by being brazed or welded thereto, and are shaped and dimensioned so that their side surfaces are in intimate contact with the inner surface of the housing 40. The hollow members 53 and 54 have discharge faces of planar configuration rounded off at their outer peripheries, as at 56 and 57 respectively, to avoid sharp edges or square corners adjacent to the surface gap 41, in this manner providing planar flat sections spaced apart in contrasting alignment to provide a non-conducting gap. The hollow members 53 and 54 are preferably rounded off at their inner peripheries, as at 58 and 59 respectively, and are made of good erosion-resistant conducting materials, or metals having a high melting point such as tungsten, molybdenum, and tantalum, or alloys of such metals.

In the spark intensifier of the invention shown in Figs. IV and V, the means provided to enhance the rapid ionization of the space between the electrodes reducing the impulse ratio of the non-conducting gap and provide a consistent break-down potential is shown in the form of a conducting plate 61 which partially surrounds the electrodes 42 and 43 in close proximity thereto but not physically connected to either, thus constituting an electrically floating element.

The electrically floating element 61 is shown in Fig. V as a thin cylindrical section, radially spaced from the electrodes by being bonded to the external surface 62 of the housing 40 circumferentially covering or encircling half of its periphery. The element 61 is symmetrically positioned and dimensioned to provide a length sufficient to bridge the gap separating the electrodes 42 and 43, and extend a slight distance therebeyond for over-lapping their ends, as particularly shown in Fig. IV.

The length of the dielectric tubular section forming the housing 40 should be correlated with respect to the dimension of the gap 41 and the length of member 61, so that flash-overs between the conducting member 61 and the electrode terminals 49 and 50 will not occur or precede the jump spark across the discharge surfaces 53 and 54. The conductor body 61 in this form of the invention is preferably produced by spraying or depositing upon the external surface 62 a non-insulating substance to provide a substantially uniform and homogeneous layer of metal or other current-conducting material. Consistent with economical manufacture, it has been found that depositing a layer of silver in solution upon the external surface of the tubular section of the dielectric support 40, and thereafter bonding or fusing the same thereto by the application of heat, produces a very effective electric floating metallic member at low cost in very close proximity to the electrodes having intimate contact with the dielectric surface 62 of the housing.

Comparative tests indicate that, while maximum effectiveness is obtained by providing the electrical floating member of the invention totally encircling the electrodes, the stability of the gap is not materially impaired when such electrical floating member is circumferentially reduced to 180 degrees. However, it has been determined that further circumferential reduction tends to decrease its effectiveness and thereby its regulating function as a stabilizing and reduction factor for the break-down voltage of the gap. Moreover, it has been found that reduction of the length of the electrical floating member has a tendency to increase the break-down potential for a given gap spacing when such reduction in length does not provide a satisfactory bridging of the gap.

It should be noted that the actual dimensions of the component elements of the embodiment of the invention herein illustrated have been materially exaggerated in the drawings for sake of clarity, being approximately five times the actual dimensions of the device.

It is to be understood that the above detailed description of the present invention is intended to disclose an embodiment thereof to those skilled in the art, but that the invention is not to be construed as limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of being practiced and carried out in various ways without departing from the spirit of the invention. The language used in the specification relating to the operation and function of the elements of the invention is employed for purposes of description and not of limitation, and it is not intended to limit the scope of the following claims beyond the requirements of the prior art.

What is claimed:

1. A device for making consistent the breakdown potential required to produce an electrical spark across a predetermined space comprising perforated electrodes having uniplanar discharge faces subjected to the atmosphere, a

perforated housing having a dielectric constant higher than air supporting said electrodes in spaced relation and directly contacting the outer surface of the uniplanar discharge faces of the electrodes, and a conducting member electrically floating carried by the outer wall of said housing and arranged to encircle and bridge the space between the uniplanar discharge faces of the electrodes.

2. A device for making consistent the breakdown potential required to produce an electrical spark across a predetermined space comprising electrodes arranged apart to provide a non-conducting gap, a spacer having a dielectric constant higher than air intervening between said electrodes and having direct engagement therewith, and a conducting member electrically floating separated from said electrodes by said spacer and being arranged to surround and bridge said non-conducting gap and a portion of the electrodes.

3. A spark gap comprising electrodes constructed and arranged to provide co-planar discharge faces spaced adjacent to each other in substantially parallel relation forming a non-conducting gap, a tubular cylindrical member having a dielectric constant higher than air directly interconnecting the peripheries of the discharge faces of the electrodes on the outside of the non-conducting gap, and an electrically floating conducting element encircling the discharge faces of the electrodes and spaced therefrom by said member, said conducting element having a length and being arranged to bridge said non-conducting gap and a portion of the electrodes.

4. A device for making consistent the breakdown potential required to produce an electric spark across a predetermined space comprising electrodes having their discharge surfaces spaced apart in axial alignment to define a predetermined spaced subjected to the atmosphere, a member of insulating material directly contacting the outer surfaces of the electrodes providing a surface gap across the predetermined spacing of the electrodes, said insulating member having a relatively high dielectric constant, and a metallic member non-conductively connected to any one of said electrodes whereby the same is electrically floating with respect thereto, said metallic member contacting the outer wall of said insulating material and having a length dimensioned to bridge said predetermined space.

5. A device for stabilizing the breakdown potential required to produce an electric spark across a predetermined space comprising two tubular electrodes having uniplanar discharge surfaces spaced apart in substantially parallel relation to define across a predetermined space on air sparking gap, an open-ended tubular member of insulating material directly contacting the outer surface of the electrodes adjacent their discharge surfaces providing a surface gap across the predetermined space separating the electrodes, said insulating member having a relatively high dielectric constant, and a tubular conducting band supported on the outer wall of said tubular member in a non-conductive relation to said electrodes whereby said band is electrically floating with respect thereto, said band having a length dimensioned to bridge said predetermined space and overlap a portion of the discharge surfaces of each of said electrodes.

6. A device for making consistent the breakdown potential required to produce an electric spark across a predetermined space comprising electrodes having their discharge faces spaced apart in axial alignment to define across a predetermined space a spark gap, each of said electrodes having a central bore whereby their discharge faces are subjected to the atmosphere, a member of insulating material embracing the electrodes by directly contacting their outer surfaces thereby providing a surface spark gap across the predetermined space separating the discharge faces of the electrodes, said insulating member being of very thin cross-section and having a relatively high dielectric constant, and a metallic body bonded to the outer surface of said member in a non-conductive relation to said electrodes whereby said body is electrically floating with respect thereto, said metallic body having a length dimensioned to bridge said surface spark gap and extend therebeyond a slight distance to overlap a portion of said electrodes.

7. A device for stabilizing the breakdown potential required to produce an electrical spark across a predetermined space comprising two cylindrical perforated electrodes having planar discharge faces spaced apart in substantially parallel relation in axial alignment to define across a predetermined space a sparking air gap, cylindrical housing of insulating material having a relatively high dielectric constant having a central bore embracing the electrodes by directly contacting their outer surfaces, said housing having a very thin cross-section between the discharge faces of the electrodes providing thereby a surface spark gap across the space separating their discharge faces, a cylindrical metallic band bonded to the outer wall of said housing, said band having a length dimensioned to bridge said surface spark gap and extend therebeyond a slight distance to overlap a portion of said electrodes without having a direct electrical connection with either whereby said metallic band is electrically floating with respect to said electrodes.

References Cited in the file of this patent

UNITED STATES PATENTS

571,099	Skinner	Nov. 10, 1896
2,290,526	Berkey	July 21, 1942
2,365,610	White	Dec. 19, 1944

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,914,695 November 24, 1959

Earl W. Meyer, Jr., et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 24, for "produces" read -- produce --; column 7, line 34, for "spaced" read -- space --.

Signed and sealed this 10th day of May 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents