

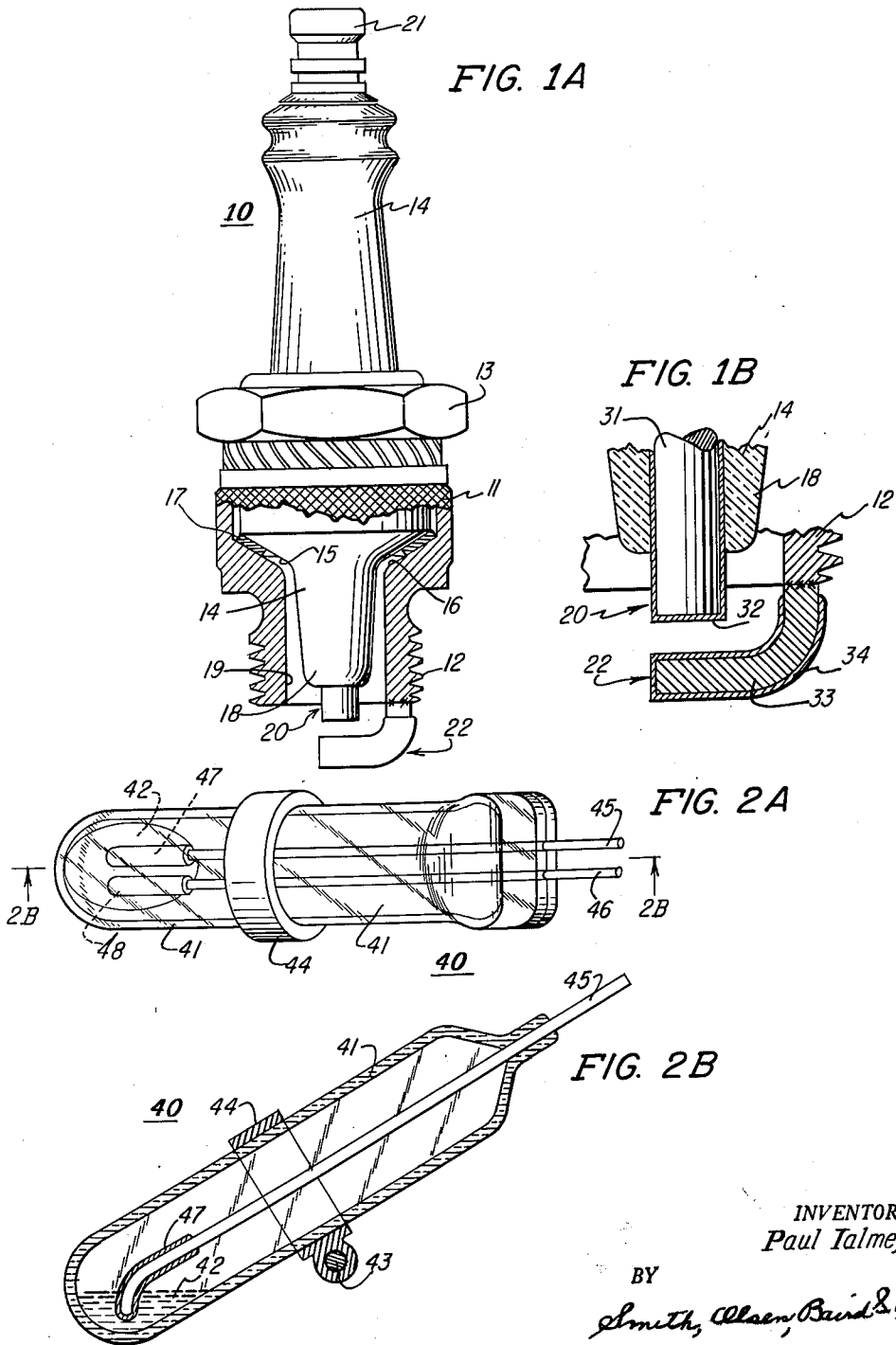
Jan. 16, 1962

P. TALMEY  
ELECTRICAL ELEMENTS

3,017,532

Filed Feb. 27, 1956

3 Sheets-Sheet 1



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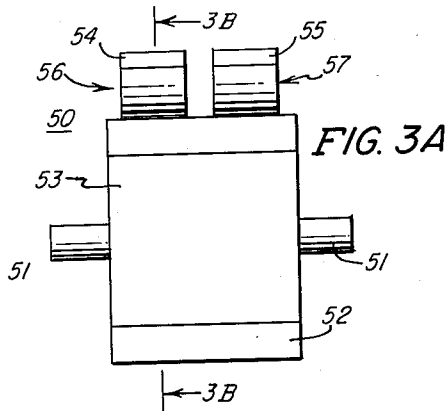
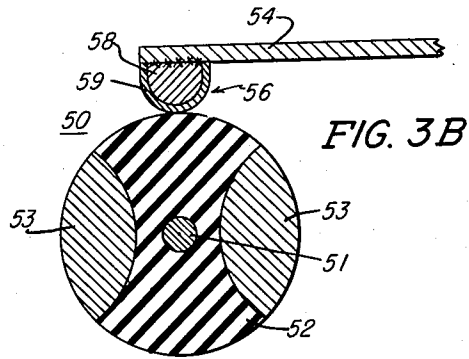
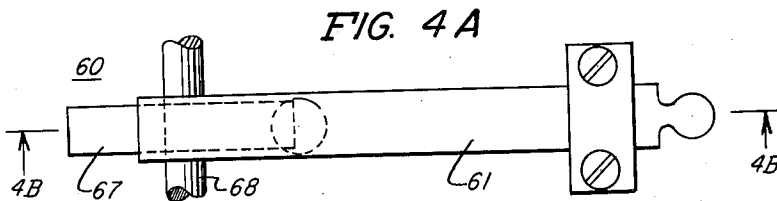
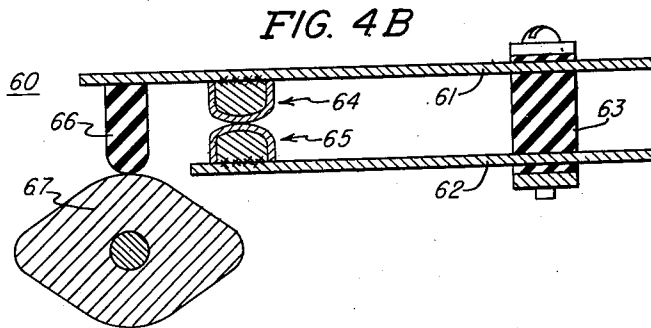
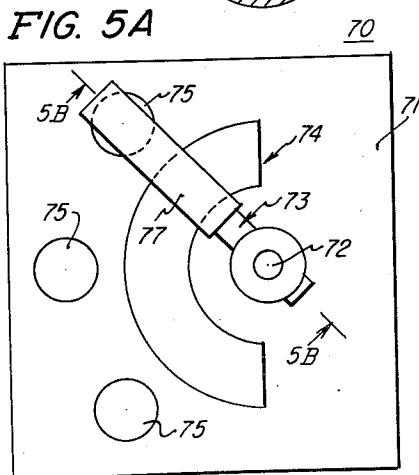
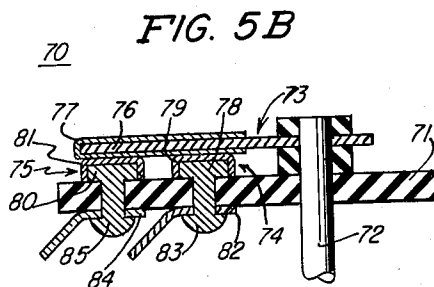
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

FIG. 6A

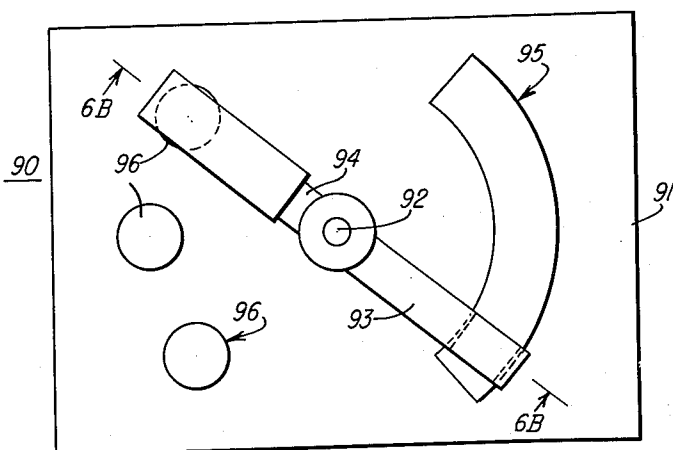
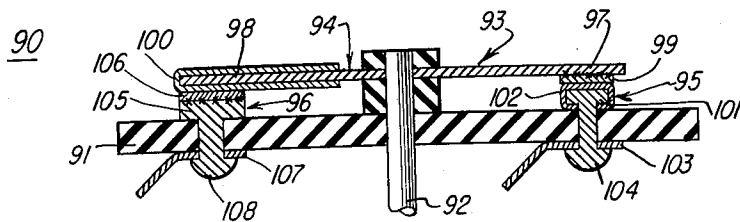


FIG. 6B



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1

3,017,532

## ELECTRICAL ELEMENTS

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Filed Feb. 27, 1956, Ser. No. 567,848  
10 Claims. (Cl. 313-141)

The present invention relates to electrical elements that are subject in use to arc discharges and more particularly to such electrical elements comprising electrodes, contacts, and the like, in electrical devices, such as spark plugs, switches, etc.

It is the general object of the invention to provide an electrical element of the character noted that comprises an arc-receiving face that consists essentially of an alloy of nickel and phosphorus.

Another object of the invention is to provide an electrical element of the character noted and comprising a current-conducting support carrying an arc-receiving layer intimately bonded thereto, wherein the support consists essentially of a base metal and the layer consists essentially of an alloy of nickel and phosphorus.

Another object of the invention is to provide an electrical element of the character noted, wherein the alloy mentioned comprises by weight about 88 to 94% nickel and 6 to 12% phosphorus and is of the character of that produced by chemical nickel plating from an aqueous chemical nickel plating bath of the nickel cation-hypophosphite anion type.

A further object of the invention is to provide in a spark plug, or the like, an electrode subject in use to conduction of an electric current of the arc-discharge type, and comprising a current-conducting support carrying an arc-receiving layer intimately bonded thereto, wherein the support consists essentially of a base metal and the layer consists essentially of an alloy of nickel and phosphorus, whereby the layer has an arc-resistant characteristic superior to that of silver and other precious metals.

A further object of the invention is to provide in an electric switch, or the like, a contact subject in use to conduction of an electric current of the arc-discharge type, and comprising a current-conducting support carrying an arc-receiving layer intimately bonded thereto, wherein the support consists essentially of a base metal and the layer consists essentially of an alloy of nickel and phosphorus, whereby the layer has both arc-resistant and wear-resistant characteristics superior to those of silver and other precious metals.

A still further object of the invention is to provide an improved contact button of the character noted that may be readily incorporated in electrical devices, such as switches, circuit breakers, etc.

Further features of the invention pertain to the particular arrangement of the component parts of the electrical element, whereby the above-outlined and additional operating features thereof are attained.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

FIGURE 1A is a side elevational view, partly broken away, of a spark plug comprising electrodes embodying the present invention;

FIG. 1B is an enlarged fragmentary view, partly in section, of the electrodes incorporated in the spark plug of FIG. 1A;

FIG. 2A is a plan view of an electric switch of the mercury-pool type comprising electrodes embodying the present invention;

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FIG. 2B is a longitudinal sectional view of the switch, taken in the direction of the arrows along the line 2B-2B in FIG. 2A;

FIG. 3A is an end elevational view of an electric switch of the commutator type comprising contacts embodying the present invention;

FIG. 3B is a lateral sectional view of the switch, taken in the direction of the arrows along the line 3B-3B in FIG. 3A;

FIG. 4A is a plan view of an electric switch of the switch-spring type comprising contacts embodying the present invention;

FIG. 4B is a longitudinal sectional view of the switch, taken in the direction of the arrows along the line 4B-4B in FIG. 4A;

FIG. 5A is a plan view of an electric switch of the selector type comprising both a wiper and contacts embodying the present invention;

FIG. 5B is a longitudinal sectional view of the switch, taken in the direction of the arrows along the line 5B-5B in FIG. 5A;

FIG. 6A is a plan view of a modified form of an electric switch of the selector type comprising both a wiper and contacts embodying the present invention; and

FIG. 6B is a longitudinal sectional view of the switch, taken in the direction of the arrows, along the line 6B-6B in FIG. 6A.

Referring now to FIGS. 1A and 1B of the drawings, there is illustrated a spark plug 10 adapted for use in the ignition system of an internal combustion engine and embodying the features of the present invention. More particularly, the spark plug 10 comprises a tubular barrel 11 formed of steel, or the like, and provided adjacent to the lower end thereof with a threaded section 12 that is adapted to be received in gas-tight relation in a corresponding threaded opening formed in the head of an engine block, the upper end of the barrel 11 being provided with a polygon section 13 adapted to receive a wrench, or the like, to facilitate placement and removal of the spark plug 10 with respect to the engine block. An elongated tubular insulating sleeve 14 formed of porcelain, or the like, is arranged within the barrel 11 and suitably secured in place, the lower end of the sleeve 14 being provided with an annular shoulder 15 that is supported by a cooperating annular shoulder 16 carried by the barrel 11, the shoulders 15 and 16 being retained in assembled relation and sealed in gas-tight relation with a suitable annular gasket 17 disposed therebetween, the gasket 17 being formed of a copper base alloy, or the like. The extreme lower end of the sleeve 14 terminates in a forwardly directed projection 18 that is disposed within a throat opening 19 formed in the extreme lower end of the section 12 of the barrel 11 and adapted to communicate with the adjacent firing chamber in the cylinder of the engine block.

A longitudinally extending center electrode 20 is sealed within a longitudinally extending center opening provided in the sleeve 14, the extreme lower end of the center electrode 20 extending beyond the adjacent end of the projection 18, and the upper end of the center electrode 20 being electrically connected to a terminal 21 carried by the upper end of the sleeve 14. Also the extreme lower end of the section 12 of the barrel 11 carries a substantially L-shaped ground electrode 22, the outer end of which is arranged below and in spaced relation with respect to the extreme outer end of the center electrode 20, so as to provide a spark or arc gap therebetween, the inner end of the ground electrode 22 being welded or otherwise supported by and electrically connected to the adjacent portion of the section 12 of the barrel 11.

In accordance with the present invention, the center electrode 20 comprises an elongated rod-like current-

conducting inner support or core 31 and an outer spark or arc-receiving layer or sheath 32 intimately bonded thereto; and the ground electrode 22 comprises an elongated rod-like current-conducting inner support or core 33 and an outer spark or arc-receiving layer or sheath 34 intimately bonded thereto. In the arrangement, the cores 31 and 33 may be formed of any suitable base metal, such, for example, as steel, copper base alloy, nickel base alloy, etc.; and the sheaths 32 and 34 are formed of an alloy of nickel and phosphorus and comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus.

In manufacturing the spark plug 10, the cores 31 and 33 are normally formed mechanically and then the layers or coatings 32 and 34 are respectively applied thereto, and ultimately the parts are assembled substantially in a conventional manner. Specifically, the coatings 32 and 34 may be applied to the respective cores 31 and 33 by chemical nickel plating employing an aqueous chemical nickel plating bath, such, for example, as disclosed in U.S. Patent No. 2,532,283, granted on December 5, 1950, to Abner Brenner and Grace E. Riddell, or in U.S. Patent No. 2,658,841, granted on November 10, 1953, to Gregoire Gutzeit and Abraham Krieg. While a wide variety of these aqueous chemical nickel plating baths are available for use for the present purpose, the particular plating bath disclosed in the copending application of Gregoire Gutzeit, Paul Talmey and Warren G. Lee, Serial No. 569,815, filed March 6, 1956, now Patent No. 2,822,294, granted on February 4, 1958, is preferred; and a typical such bath comprises an aqueous solution containing:

|                                                        |            |
|--------------------------------------------------------|------------|
| Nickel ion (as nickel sulfate)-----m.p.l.              | 0.07       |
| Hypophosphite ion (as sodium hypophosphite)-----m.p.l. | 0.23       |
| Lactic ion (as lactic acid)-----m.p.l.                 | 0.30       |
| Propionic ion (as propionic acid)-----m.p.l.           | 0.03       |
| Initial pH-----                                        | 4.4 to 5.6 |

This plating bath is normally utilized at a temperature of about 98° C. and has a plating rate of about 1 mil (0.001") per hour. As indicated, the cores 31 and 33 must be formed of materials that are catalytic to this reaction (iron, copper, nickel, etc., or alloys thereof); whereby, upon immersion of the cores 31 and 33 in the hot plating bath mentioned, the coatings 32 and 34 are respectively deposited thereupon at a rate of about 1 mil per hour. Of course, it follows that in order to produce the coatings 32 and 34 having thicknesses of several mils, it is only necessary to effect immersion of the respective cores 31 and 33 during a corresponding number of hours in the plating bath. The coatings 32 and 34 are tenaciously bonded in intimate contact with the respective cores 31 and 33 and essentially comprise an alloy of nickel and phosphorus of somewhat variable content depending upon the composition of the plating bath but within the approximate range previously noted with respect to the content of nickel and phosphorus.

These coatings 32 and 34 are essentially different from electrodeposited nickel coatings in many respects aside from the alloy character thereof, including phosphorus; and specifically, they are substantially harder than electrodeposited nickel coatings and have a substantially higher specific resistance than electrodeposited nickel coatings. Specifically, a chemically deposited nickel-phosphorus alloy coating of the character described has a hardness corresponding to a Vickers pyramid No. (V.P.N.) of about 525 to 1000, depending upon heat treatment, a melting point in the general range 880° to 1125° C., depending upon composition, and a resistivity of about 60-microhm-cm. at 20° C. Additional physical characteristics of this nickel-phosphorus alloy are disclosed in the copending application of Paul Talmey and William J. Crehan, Serial No. 514,588, filed June 10, 1955, and in the copending application of William J.

Crehan, Walter F. Klouse and Paul Talmey, Serial No. 514,472, filed June 10, 1955.

Furthermore, a nickel-phosphorus alloy layer of the character described is considerably more resistant to erosion and pitting due to spark discharges or arc discharges than are precious metals, such as silver, etc., and special alloys of such metals as tungsten, molybdenum, etc., that have been used heretofore for the present purpose.

In the manufacture of the spark plug 10, the coatings 32 and 34 normally have a thickness of about 1 to 3 mils, although this dimension is not critical as long as the thickness thereof is adequate to impart the desired arc-resistant characteristic to the electrodes 20 and 22.

In order to demonstrate the advantages of the present invention, life tests were conducted in an internal combustion engine of an automobile utilizing three conventional spark plugs and three inventive spark plugs of the construction previously described and illustrated in FIGS. 1A and 1B, the center electrodes and the ground electrodes of the inventive spark plugs being provided with the nickel-phosphorus alloy coatings of 0.001" thickness. All of the spark plugs were of the same manufacture and background structure "Auto-Lite" resistor-type; all of the spark gaps were initially set at 0.030"; and spark gap measurements were made twice during the test. After 5,249 miles of use of the automobile, measurements of the spark gaps of the spark plugs were made, and it was discovered that in the conventional spark plugs, the spark gaps ranged from 0.037" to 0.038", while in the inventive spark plugs, the spark gaps ranged from 0.032" to 0.033". After 7,639 miles of use of the automobile, measurements of the spark gaps of the spark plugs were made, and it was discovered that in the conventional spark plugs, the spark gaps were uniformly about 0.050", while in the inventive spark plugs, the spark gaps were uniformly about 0.035". Accordingly, during the test: the spark gap between the electrodes of a conventional spark plug was increased by burning from 0.030" to about 0.050", while the spark gap between the electrodes of the inventive spark plug was increased by burning from 0.030" to about 0.035".

In another series of tests employing "Champion J-7" spark plugs in a stationary engine, "Briggs and Stratton Model 6FB," conventional and inventive spark plugs were compared. In these tests, all of the spark gaps were initially set at 0.025" and the electrodes of the inventive spark plugs carried coatings of the character described of 0.001" thickness. After 350 hours of use of this engine: the spark gaps in the conventional spark plugs had increased from 0.025" to 0.045" by burning, and the surfaces of the electrodes were rough, irregular and non-parallel; while the spark gaps in the inventive spark plugs had increased from 0.025" to 0.035" by burning, and the surfaces of the electrodes were smooth, regular and parallel.

In these tests, it was apparent that the nickel-phosphorus alloy coatings provided upon the electrodes 20 and 22 of the spark plug 10 are substantially more resistant to burning than are the uncoated electrodes of a conventional spark plug; there was a definite tendency to reduce substantially the amount of carbon deposit upon the coated electrodes 20 and 22 of the spark plug 10; and the utilization of the inventive spark plug 10 contributed substantially to smooth engine performance.

Another very peculiar phenomenon was observed in these tests that is not altogether understood, concerning the circumstance that an electrode having a coating of a thickness of only 0.001" can withstand burning away of 0.002" to 0.003" of the surface thereof, without the total burning away of the coating. In other words, the nickel-phosphorus alloy seems to become absorbed or diffused in the surface of the electrode as the metal of the electrode is burned away. In any case, and without reference to the mechanism of the phenomenon, this characteristic is very

advantageous as a coating of 1 mil initial thickness is not interrupted even though 3 mils of the surface of the electrode has been burned away by the arc or spark discharges produced in the operation of the spark plug; whereby the 1 mil coating of the nickel-phosphorus alloy gives the surface of the electrode greater protection against pitting and roughening in operation than do precious metal and other conventional coatings of several mils in thickness.

Referring now to FIGS. 2A and 2B, there is shown an electric switch 40 of the mercury-pool type embodying the features of the present invention and comprising an elongated enclosing envelope 41 formed of glass, or the like, and containing a mercury pool 42, the envelope 41 being mounted for tilting movement upon an exterior pivot pin 43 by an arrangement including a supporting band 44. Also the switch 40 comprises a pair of electrodes 45 and 46 extending from the exterior through one end of the envelope 41 and sealed in place therein. The envelope 41 is hermetically sealed and contains a suitable charge of an inert gas, such as argon. The outer ends of the electrodes 45 and 46 serve as terminals, while the inner ends thereof cooperate with the mercury pool 42 for the circuit-making and circuit-breaking purpose. The inner ends of the electrodes 45 and 46 carry respective coatings or sheaths 47 and 48 formed of the previously-described nickel-phosphorus alloy and having a thickness in the general range 1 to 3 mils; whereby the extreme inner ends of the electrodes 45 and 46 are encased by the respective sheaths 47 and 48 that make the electrical connections with the mercury pool 42.

In the operation of the switch 40, when the envelope 41 occupies its downwardly tilted position, as illustrated in FIG. 2B, the coatings 47 and 48 establish electrical contacts with the mercury pool 42, thereby to complete an electric circuit between the electrodes 45 and 46. On the other hand, when the envelope 41 is rotated in the clockwise direction, from its position as shown in FIG. 2B, the mercury pool 42 runs or flows away from the coatings 47 and 48, interrupting the electric circuit through the mercury pool 42 between the electrodes 45 and 46.

The mercury tilting switch 40 is very advantageous in view of the fact that the nickel-phosphorus coatings 47 and 48 have an arc-resistant characteristic that is substantially greater than that of ordinary electrode materials, such as silver, copper, nickel, etc. In fact, in accordance with the present arrangement, it is entirely feasible that the electrodes 45 and 46 may comprise steel wires or rods carrying the chemically deposited nickel-phosphorus coatings 47 and 48 on the inner ends thereof, as illustrated.

The manufacture of the switch 40 is substantially the same as that of conventional switches of this type with respect to the assembly of the elements after the formation thereof.

Referring now to FIGS. 3A and 3B, there is shown an electric switch 50 of the commutator type embodying the features of the present invention and comprising a rotatable operating shaft 51 carrying a substantially drum-like insulating cam 52 that, in turn, carries a plurality of conducting segments 53 arranged in circumferentially spaced-apart relation. Also the switch 50 comprises two contact springs 54 and 55 that respectively carry two contacts 56 and 57 that cooperate with the periphery of the cam 52.

In the arrangement, the contacts 56 and 57 are identical, the contact 56 comprising, as best shown in FIG. 3B, a contact button including a support or core 58 and an outer layer or sheath 59, the core 58 being suitably secured, as by welding, to the extreme outer end of the switch springs 54. In the construction: the switch spring 54 may be formed of steel, brass, etc.; likewise the core 58 may be formed of steel, brass, etc.; and the sheath 59 is formed of the previously-mentioned nickel-phosphorus alloy. Specifically, the core 58 may be provided

with the coating 59 by chemical nickel plating in the manner previously explained, the coating 59 having a thickness in the general range 1 to 3 mils; and thereafter the composite contact button 56 is suitably secured, as by welding, to the extreme outer end of the contact spring 54.

In the operation of the switch 50, it will be understood that the contacts 56 and 57 are pressed into running engagements with the periphery of the cam 52 by the resiliency of the switch springs 54 and 55; and as the operating shaft 51 is rotated, the conducting segments 53 alternately engage and disengage the contacts 56 and 57, thereby completing intermittently an electric circuit between the switch springs 54 and 55. In the switch 50, the contacts 56 and 57 are subjected not only to an arc discharge as the contact segments 53 disengage the contacts 56 and 57, but they are also subjected to considerable mechanical wear; whereby the formation of the coatings upon the cores of the contacts 56 and 57 of the nickel-phosphorus alloy mentioned is very advantageous, since the same not only possesses the high arc-resistant characteristic previously noted, but it also possesses a very high wear-resistant characteristic. In fact, the wear-resistant characteristic of a nickel-phosphorus alloy of the character mentioned is considerably greater than that of comparable conventional contact materials, such as copper, silver, etc.

Referring now to FIGS. 4A and 4B, there is shown an electric switch 60 of the switch-spring type embodying the features of the present invention and comprising two resilient switch springs 61 and 62 mounted adjacent to the inner ends thereof upon stationary insulating structure 63 and respectively carrying two contact buttons 64 and 65 adjacent to the outer ends thereof. The extreme outer end of the switch spring 61 projects beyond the extreme outer end of the switch spring 62 and carries an insulating follower 66 that cooperates with a control cam 67 carried by a rotatably mounted operating shaft 68.

In the arrangement: the contacts 64 and 65 are biased into engagement by the resiliency of the switch springs 61 and 62; and the switch spring 61 is moved away from the switch spring 62, as the high lobe of the cam 67 rotates under the follower 66; whereby rotation of the operating shaft 68 effects alternate movements of the switch spring 61 toward and away from the switch spring 62, so that the contacts 64 and 65 are moved respectively into engagement and disengagement respectively completing and interrupting an electric circuit between the switch springs 61 and 62 in a well-known manner.

In this arrangement, the contacts 64 and 65 are identical and comprise contact buttons of the construction previously described including the inner core or support formed of base metal and the outer layer or sheath formed of the nickel-phosphorus alloy.

Referring now to FIGS. 5A and 5B, there is shown an electric switch 70 of the selector type embodying the features of the present invention and comprising a supporting insulating plate 71 carrying a rotatably mounted operating shaft 72 provided with a radially extending and outwardly directed resilient wiper 73. Also the insulating plate 71 carries an arcuately disposed contact segment 74 and a plurality of circumferentially spaced-apart contacts 75, the arcuate segment 74 being disposed radially inwardly with respect to the contacts 75 and cooperating with the wiper 73, and the contacts 75 selectively cooperating with the wiper 73.

In the operation of the switch 70, it will be understood that as the operating shaft 72 is rotated, the outer end of the wiper 73 selectively engages the contacts 75 and constantly engages the arcuate segment 74, whereby an electric circuit is selectively established between the arcuate segment 74 and the respective contacts 75 via the wiper 73 in the respective rotary positions of the operating shaft 72.

In the arrangement, the wiper 73 comprises an inner support or core 76 formed of a base metal and an outer

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layer or sheath 77 formed of the previously-described nickel-phosphorus alloy; similarly, the arcuate segment 74 comprises an inner support or core 78 formed of a base metal and an outer layer or sheath 79 formed of the previously-described nickel-phosphorus alloy; and each of the contacts 75 comprises an inner support or core 80 formed of a base metal and an outer layer or sheath 81 formed of the previously-described nickel-phosphorus alloy. Of course, the coating 77 carried by the wiper 73 is in constant frictional engagement with the coating 79 carried by the arcuate segment 74; while the coating 77 selectively frictionally engages the coatings 81 respectively carried by the contact 75 for the circuit selection purpose, previously described.

In the switch 70, the arcuate segment 74 may be secured in place upon the wiper side of the insulating plate 71 by a terminal strip 82 disposed on the opposite side thereof, together with a plurality of conducting rivets 83 extending through corresponding openings provided through the plate 71; while each of the contacts 75 may be secured in place upon the wiper side of the insulating plate 71 by a corresponding terminal washer 84 disposed on the opposite side thereof, together with a corresponding conducting rivet 85 extending through a corresponding opening provided through the plate 71.

In the manufacture of the switch 70, it will be understood that the support 76 of the wiper 73 is provided with the coating 77, the support 78 of the conducting segment 74 is provided with the coating 79 and the support 80 of each of the contacts 75 is provided with the coating 81, prior to the assembly of the parts upon the plate 71, each of the coatings mentioned having a thickness in the general range 1 to 3 mils.

The construction and arrangement of the switch 70 is very advantageous in view of the fact that the various coatings mentioned formed of the nickel-phosphorus alloy described have both a wear-resistant characteristic and high arc-resistant characteristic, as previously explained.

In the foregoing description of the nickel-phosphorus alloy coatings or layers applied to the electrodes, contacts and wipers described, it was explained that the same were produced by chemical nickel plating; and this is the preferred procedure, as noted. However, this nickel-phosphorus alloy may be produced independently of chemical nickel plating, as disclosed in the Crehan, Klouse and Talmey application, and then the alloy thus produced may be suitably applied to the electrode, contact or wiper in any suitable manner. Specifically, as disclosed in the Crehan, Klouse and Talmey application, when a chemical nickel plating bath of the character previously described is spent, decomposition thereof may be induced by introducing therein a small amount of palladium chloride, whereby a black metallic precipitate forms throughout the plating bath. Upon filtering the plating bath, the metallic precipitate may be separated from the aqueous filtrate; and upon melting of this metallic precipitate, the nickel-phosphorus alloy described is produced; which nickel-phosphorus alloy may be cast into desired forms and may be applied to metallic surfaces by brazing, hot-dipping, etc., steps.

These considerations will be better understood in conjunction with the electric switch 90 shown in FIGS. 6A and 6B, and embodying the features of the present invention. More particularly, the switch 90 is of the selector type comprising a supporting insulating plate 91 carrying a rotatably mounted operating shaft 92 provided with oppositely extending wipers 93 and 94. Also the insulating plate 91 carries an arcuately disposed contact segment 95 constantly cooperating with the wiper 93 and a plurality of circumferentially spaced-apart contacts 96 selectively cooperating with the wiper 94, the arcuate segment 95 and the contacts 96 being disposed on opposite sides of the operating shaft 92.

In the operation of the switch 90, it will be understood that as the operating shaft 92 is rotated the outer end of

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the wiper 93 constantly engages the arcuate segment 95, while the outer end of the wiper 95 selectively engages the contacts 96, whereby an electric circuit is selectively established between the arcuate segment 95 and the respective contacts 96 via the connected wipers 93 and 94 in the respective rotary positions of the operating shaft 92.

In the arrangement, the wipers 93 and 94 comprise a common support 97—98 formed of a resilient base metal, such as brass, steel, etc. The wiper 93 further comprises a contact 99 formed of the nickel-phosphorus alloy previously described and suitably secured to the support 97, as by welding; and preferably the contact 99 consists essentially of a cast body of the preformed nickel-phosphorus alloy described. The wiper 94 further comprises an outer layer or sheath 100 formed of the previously described nickel-phosphorus alloy and carried by the inner support or core 98; which layer 100 may be applied to the support 98 by a hot dipping step.

The arcuate segment 95 comprises a composite structure including an inner support or core 101 formed of a base metal, such as brass, steel, etc., and an outer layer or sheath 102 formed of the previously described nickel-phosphorus alloy and applied thereto by chemical nickel plating. The arcuate segment 95 is secured in place upon the wiper side of the insulating plate 91 by a terminal strip 103 disposed on the opposite side thereof, together with a plurality of conducting rivets 104 extending through corresponding openings provided through the plate 91.

Each of the contacts 96 comprises a support 105 formed of a base metal, such as brass or steel, and carrying a contact 106 formed of the nickel-phosphorus alloy previously described and suitably secured to the support 105 as by welding; and preferably the contact 106 consists essentially of a cast body of the preformed nickel-phosphorus alloy described. Each of the contacts 96 is secured in place upon the wiper side of the insulating plate 91 by a corresponding terminal washer 107 disposed on the opposite side thereof, together with a corresponding conducting rivet 108 extending through a corresponding opening provided through the plate 91.

In the arrangement, it will be understood that the contact 99 carried by the support 97 is in constant engagement with the sheath 102 carried by the support 101 to provide the cooperating relation between the wiper 93 and the arcuate segment 95. Similarly, the sheath 100 carried by the core 98 of the wiper 94 selectively engages the contact faces 106 respectively carried by the supports 105 in the respective composite contacts 96 for the selection purpose.

In the manufacture of the switch 90, it will be understood that the support 97 of the wiper 93 is provided with the contact 99, the support 98 of the wiper 94 is provided with the sheath 100, the core 101 of the arcuate segment 95 is provided with the sheath 102 and the support 105 of each of the contacts 96 is provided with the corresponding contact face 106, prior to the assembly of the parts upon the plate 91. In the arrangement, the coating or sheath 102 may have a thickness in the general range 1 to 3 mils; the sheath or coating 100 may have a thickness in the general range 3 to 10 mils, and the contacts 99 and 106 normally have a thickness in the general range 5 to 25 mils.

The construction and arrangement of the switch 90 is very advantageous in view of the fact that the various coatings and contacts mentioned formed of the nickel-phosphorus alloy described have both a high wear-resistant characteristic and a high arc-resistant characteristic, as previously explained.

In view of the foregoing, it is apparent that there has been provided in an electrical device, an electrical element subject in use to an arc discharge, and comprising and arc-receiving face of improved composition and consisting essentially of an alloy of nickel and phosphorus of the character described and possessing a high arc-resistant characteristic.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An electrical device comprising a pair of electrodes between which there is produced in use an arc discharge, at least one of said electrodes comprising a current-conducting inner core and an arc-receiving outer sheath intimately bonded thereto, said core being formed essentially of a base metal and said sheath being formed essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus, said sheath having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said core.

2. An electrical device comprising a pair of electrodes between which there is produced in use an arc discharge, each of said electrodes comprising a current-conducting inner core and an arc-receiving outer sheath intimately bonded thereto, each of said cores being formed essentially of a base metal and each of said sheaths being formed essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus, said sheaths having thicknesses of at least about 1 mil so as to afford substantial protection against pitting to said cores.

3. An electric switch comprising a pair of contacts selectively movable into circuit-making and circuit-breaking relations with respect to each other, at least one of said contacts comprising a current-conducting inner support and an arc-receiving outer layer intimately bonded thereto, said support being formed essentially of a base metal and said layer being formed essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus, said layer having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said support.

4. In combination, a pair of cooperating base metal electrical contact elements, and a chemically plated arc-receiving outer layer of nickel-phosphorus alloy carried by at least one of said elements, said alloy comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus, said layer having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said one element.

5. In an electric switch, a contact element comprising a current-conducting inner support and an arc-receiving outer layer intimately bonded thereto, said support being formed essentially of a base metal and said layer being formed essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus, said layer having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said support.

6. An electric contact comprising a current-conducting inner support and a contact-making and contact-breaking outer layer intimately bonded thereto, said support being formed essentially of a base metal and said layer being formed essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus, said layer having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said support.

7. In an electric switch, a movable wiper element comprising a resilient current-conducting inner support

carrying a contact-engaging outer layer intimately bonded thereto, said support being formed essentially of a base metal and said layer being formed essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88 to 94% nickel and 6 to 12% phosphorus, said layer having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said support.

8. In a spark plug including a pair of electrodes arranged in cooperating spaced-apart relation; the combination wherein at least one of said electrodes comprises a current-conducting core carrying an arc-receiving sheath intimately bonded thereto, said core consisting essentially of a base metal and said sheath consisting essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88% to 94% nickel and 6% to 12% phosphorus, said sheath having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said core.

9. In a spark plug including a pair of electrodes arranged in cooperating spaced-apart relation; the combination wherein each of said electrodes comprises a current-conducting core carrying an arc-receiving sheath intimately bonded thereto, each of said cores consisting essentially of a base metal and each of said sheaths consisting essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88% to 94% nickel and 6% to 12% phosphorus, said sheaths having thicknesses of at least about 1 mil so as to afford substantial protection against pitting to said cores.

10. In an electric switch including an electrode and a cooperating mercury pool selectively movable relative to each other into contact-making relation and contact-breaking relation; the combination wherein said electrode comprises a current-conducting core carrying an arc-receiving sheath intimately bonded thereto, said core consisting essentially of a base metal and said sheath consisting essentially of a nickel-phosphorus alloy, said alloy comprising by weight about 88% to 94% nickel and 6% to 12% phosphorus, said sheath having a thickness of at least about 1 mil so as to afford substantial protection against pitting to said core.

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