July 21, 1959 S. M. SEGAL 2,896,108

APPARATUS EMPLOYING HORIZONTALLY ELONGATED CARBON ARC SOURCES

Filed Jan. 31, 1957 3 Sheets-Sheet 1

Fig. 1.

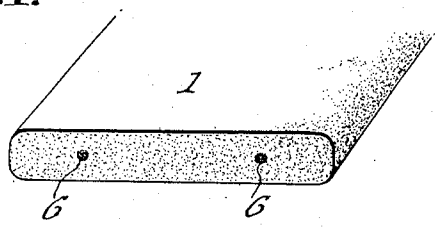


Fig. 2.

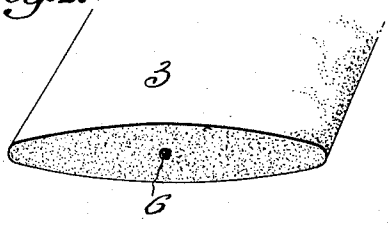


Fig. 3.

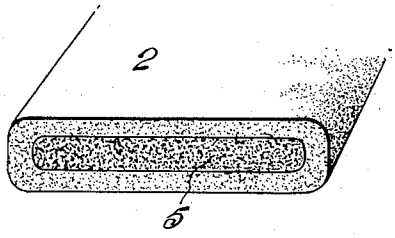
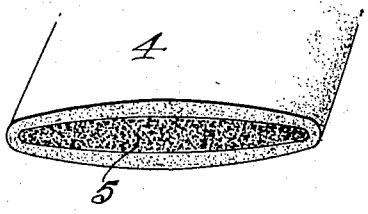


Fig. 4.



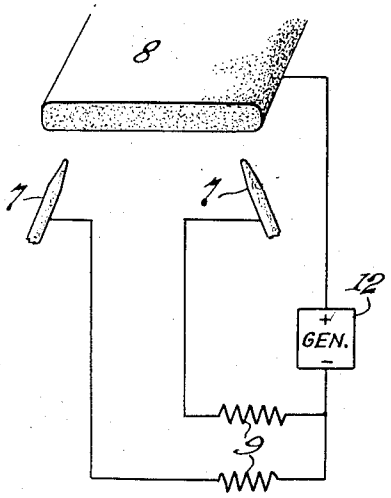


Fig. 5.

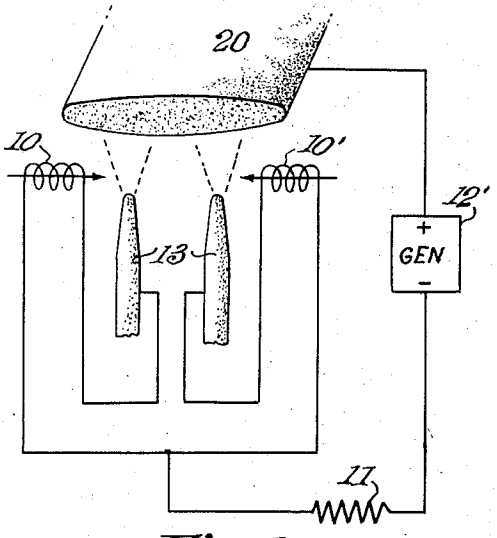


Fig. 6.

INVENTOR.
Stanley M. Segal
BY Spillard & Kelly Jr
Rainford Hamilton

ATTORNEYS

July 21, 1959 S. M. SEGAL 2,896,108

APPARATUS EMPLOYING HORIZONTALLY ELONGATED CARBON ARC SOURCES

Filed Jan. 31, 1957 3 Sheets-Sheet 2

Fig. 7.

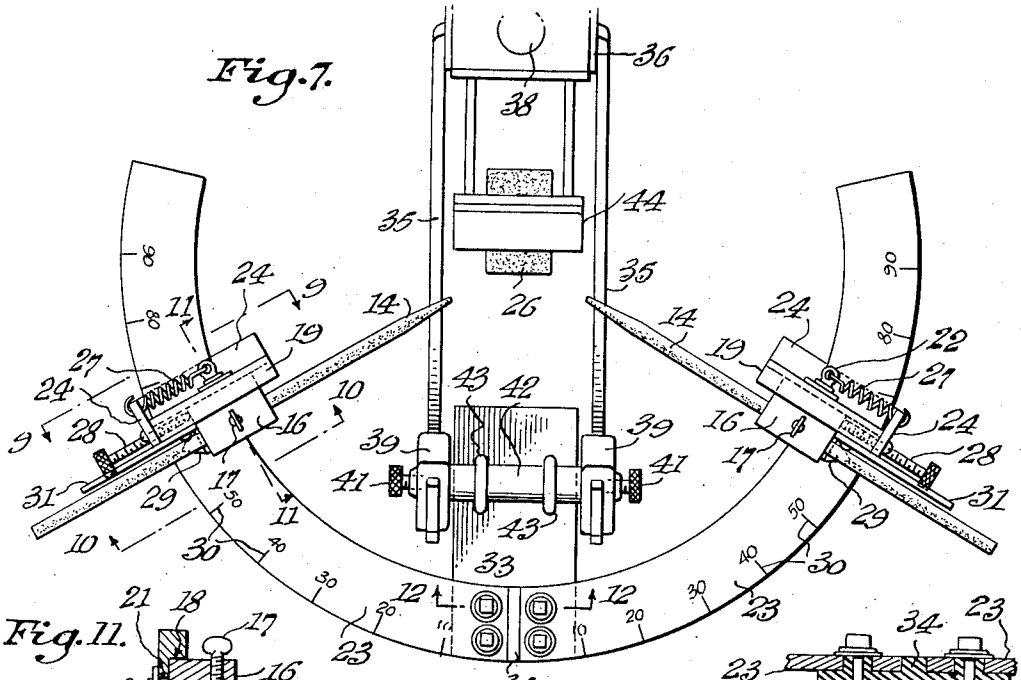


Fig. 11.

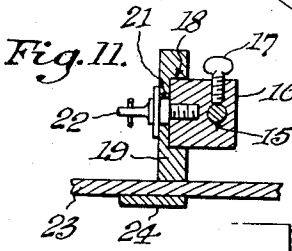


Fig. 12.

Fig. 8.

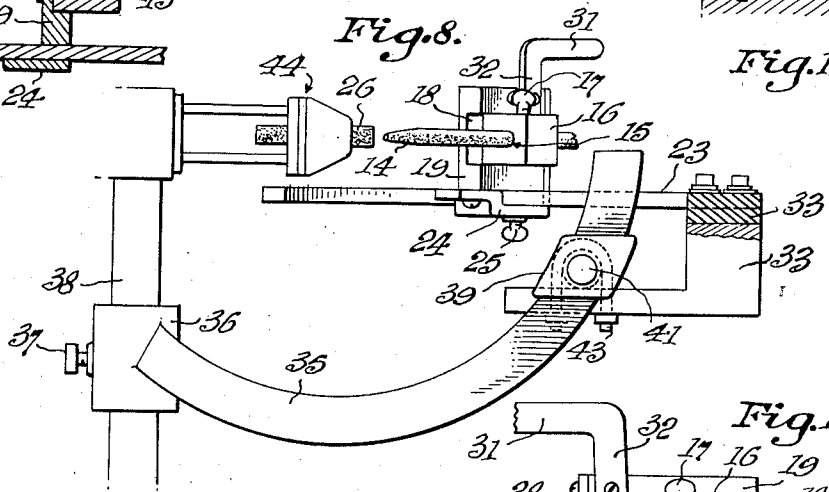


Fig. 10.

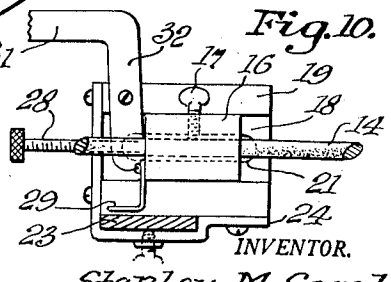
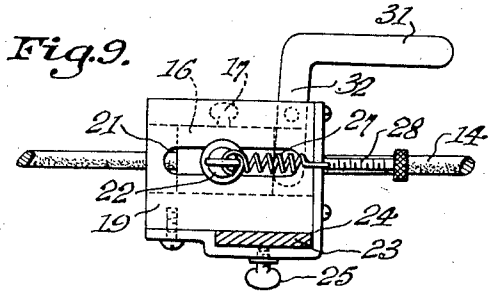


Fig. 9.



INVENTOR.

Stanley M. Segal

BY

ATTORNEYS

July 21, 1959 S. M. SEGAL 2,896,108

APPARATUS EMPLOYING HORIZONTALLY ELONGATED CARBON ARC SOURCES

Filed Jan. 31, 1957 3 Sheets-Sheet 3

Fig. 13.

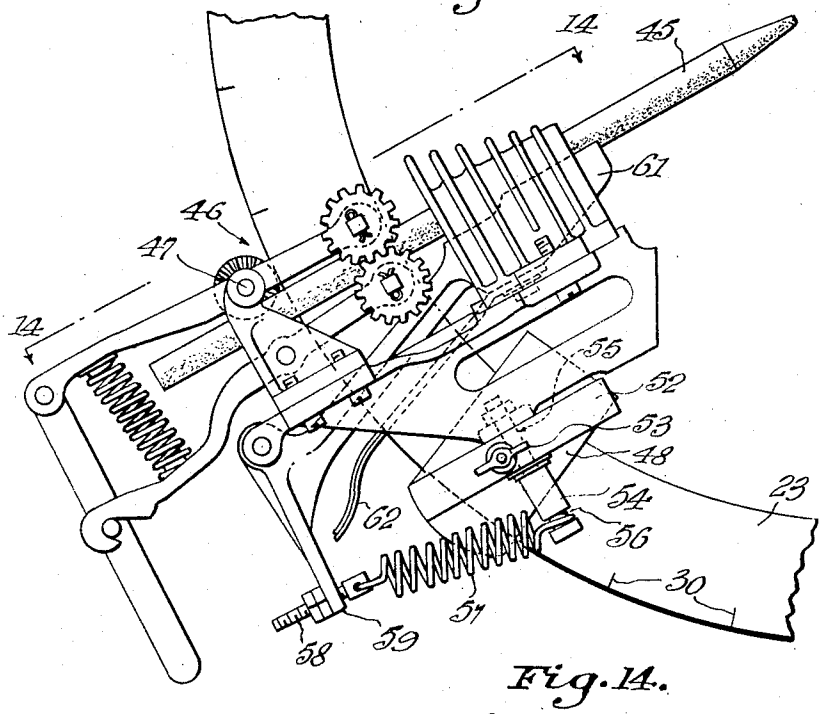
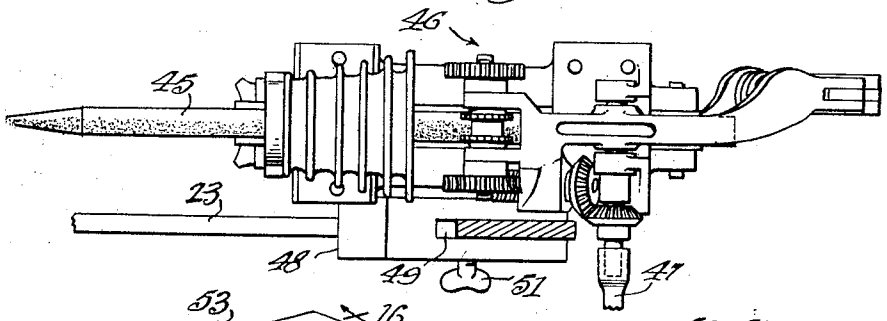


Fig. 14.



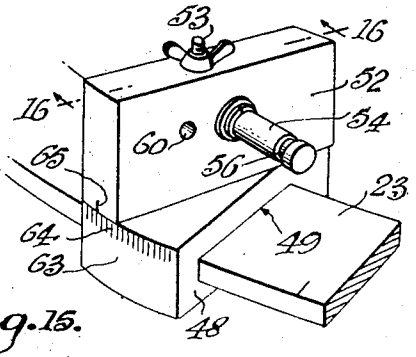


Fig. 15.

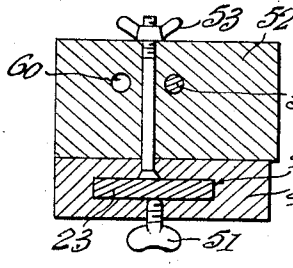


Fig. 16.

INVENTOR.
Stanley M. Segal
BY Willard G. Hayes Jr.
Bonfield Hamilton

ATTORNEYS

United States Patent Office 2,896,108
Patented July 21, 1959

2,896,108

APPARATUS EMPLOYING HORIZONTALLY ELONGATED CARBON ARC SOURCES

Stanley M. Segal, Springfield, Va.

Application January 31, 1957, Serial No. 637,583

8 Claims. (Cl. 314—47)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to illuminating sources and more particularly to a structure employing a horizontally elongated carbon electrode and apparatus facilitating the use of such carbon electrodes in searchlight and floodlight equipment. The structure herein described permits realizing the advantages of the principles and structure taught by the instant invention for military and commercial applications.

Present carbon arc searchlights use a round source. The beam is a narrow cone. To spread the beam, the source, usually used in conjunction with a parabolic reflector, is moved out of focus. An alternative method is to use spread lenses in the front window of the searchlight. Either of these two methods spreads the beam with a very large percentage reduction in beam candlepower. By using a rectangular source, such as in the instant invention, the spread beam is realized withoct any loss in beam candlepower due to forming the light source by the use of the brighter electrode crater rather than an arc stream. The ratio of the horizontal to vertical dimensions of the horizontally elongated carbon depends on the particular application. For a very wide spread beam, the extremities of the source would be out of focus in which case a spherical instead of a parabolic reflector could be used in conjunction with a correcting front window.

Experimentation with horizontally elongated positive carbon electrodes has shown that the use of a single negative electrode will cut deep concave curves or craters in the positive electrode after short periods of operation, from 30 seconds to 2 minutes. The curves and craters are due to more rapid burning or evaporation in the areas on which the electron stream impinges. If an elongated negative electrode is used the negative foot-point, or point on the electrode from which the stream of electrons leaves, will slide along and slip off an elongated negative electrode. If the negaitve foot-point is kept stationary by some special means, such as magnetic fields, etc., the elongated negative electrode would then function like the conventional electrode. Whether an elongated negative electrode is used or the negative foot-point is controlled, the stream of electrons will only leave the negative electrode from a small spot causing uneven conscmption of a positive electrode that has an elongated cross-section.

It was discovered that the uneven burning could be overcome by the use of a plurality of negative electrodes and that concave, straight or convex burning ends could be maintained as desired by operating with predetermined horizontal angles with respect to the longitudinal axis of the positive electrode. Zero degrees appears to be the optimum vertical angle. It was further discovered that the whole rectangular cross-section of a horizontally elongated carbon electrode could be ignited

with even brilliance and quiet operation by selection of proper arc parameters, such as arc length, voltage, current and negative electrode angle.

It is a primary object of the present invention to provide a carbon arc source with a substantial horizontal elongation.

It is a further object of the present invention to provide a light source for producing horizontally elongated beams of light of high brightness and high infrared intensity per unit area without beam distortion.

It is a further object of the present invention to provide a light source employing horizontally elongated carbon electrodes for producing horizontally elongated beams of light of uniform beam candlepower without beam distortion.

It is a further object of the present invention to provide a light source employing a horizontally elongated positive carbon electrode which operates with uniform brightness per unit area.

It is another object of the present invention to provide a carbon arc source employing a horizontally elongated positive carbon electrode wherein the positive electrode consumption may be controlled.

It is a still further object of the present invention to provide a carbon arc source employing a horizontally elongated positive carbon electrode wherein end burning of the positive electrode may be controlled to produce a desired configuration.

It is another object of the present invention to provide a carbon arc source employing a horizontally elongated positive carbon electrode and a plurality of negative electrodes to produce uniform burning and brightness per unit area of the positive electrode.

It is a further object of the present invention to provide a carbon arc source employing a horizontally elongated positive carbon electrode and a plurality of negative electrodes adjustable in horizontal angle relative to the positive electrode to provide controlled consumption of the positive electrode.

It is also an object of the present invention to provide horizontally elongated carbon electrodes having a high ratio of length to width.

It is also an object of the present invention to provide horizontally elongated carbon electrodes for high and low current operation.

It is a further object to provide horizontally elongated carbon electrodes of predetermined spectral characteristics.

These and other objects will become apparent as the description proceeds wherein—

Fig. 1 shows a section through a solid horizontally elongated carbon electrode;

Fig. 2 shows a section through a solid horizontally elongated carbon electrode with tapered ends;

Fig. 3 shows a section through a cored horizontally elongated carbon electrode;

Fig. 4 shows a section through a cored horizontally elongated carbon electrode with tapered ends;

Fig. 5 is a diagram of one form of circuit to provide independent energization of each of a plurality of carbon electrodes;

Fig. 6 is a diagram of a form of circuit for transferring the arc among plural negative electrodes when such electrodes are connected in parallel to a single source;

Fig. 7 is a plan view of a horizontal angle adjustment mechanism;

Fig. 8 is an elevational view, partly in section, of a vertical angle adjustment mechanism;

Fig. 9 is a view taken on the line 9—9 of Fig. 7;

Fig. 10 is a view taken on the line 10—10 of Fig. 7;

Fig. 11 is a vertical section taken on the line 11—11 of Fig. 7;

Fig. 12 is a vertical section taken on the line 12—12 of Fig. 7;

Fig. 13 is a plan view of a motor-driven type of negative electrode holder mounted for horizontal angle adjustment;

Fig. 14 is an elevational view taken on the line 14—14 of Fig. 13;

Fig. 15 is a perspective view of a horizontal angular adjustment device for the motor-driven type of negative electrode holder shown in Fig. 13; and

Fig. 16 is a vertical section taken on the line 16—16 of Fig. 15.

Reference is now made to Figs. 1–4 showing two configurations of horizontally elongated positive carbon electrodes. Various ratios of the horizontal to vertical dimensions of horizontally elongated positive carbon electrodes were tried, such as 32 mm. x 3 mm., 32 mm. x 6 mm., 1 inch x ⅛ inch and 1 inch x ¼ inch.

The conventional mercury capillary arc source measures 25.5 mm. x 1.5 mm. The mercury capillary arc source is satisfactory for certain applications but fails in brightness and spectral characteristics for other applications and exhibits too narrow a vertical beam spread for certain applications.

In general, if the ratio is unity a single negative electrode is advisable and as the ratio increases the number of negative electrodes increases. In a particular application in which the ratio was 6:1, two negative electrodes were used. With rectangular carbon electrodes **1** and **2** as in Figs. 1 and 3, respectively, plural negative electrodes are used to assure uniform consumption of the positive electrode and unform brightness. In order to overcome the rapid central evaporation of rectangular electrodes when using a single negative electrode, tapered positive electrodes, such as **3** and **4**, in Figs. 2 and 4, respectively, were used. It was found that the tapered or oval positive electrodes **3** and **4** would operate with a single negative electrode but only with marginal improvement over a rectangular electrode using a single negative.

As previously discussed, it may be desirable to maintain straight, concave or convex burning ends on the positive carbon by varying the horizontal angle of the individual negative electrodes relative to the positive carbon electrode by means which will be more fully described hereinafter.

Certain difficulties may arise when using plural negative electrodes such as the need for individual ballasts or resistors and difficulty in striking the arc. Further, a simultaneous strike may draw too much current and with successive strikes the second strike may extinguish the first arc by a momentary drain on the total current and sudden unbalance in magnetic fields for operating the arc. Also, even though both negatives are conducting, there may be a tendency for the arc of one negative to combine with the arc of the other before approaching the anode or positive electrode. These difficulties may all be overcome by proper selection of arc parameters such as arc length, voltage, current and negative electrode angle.

Positive horizontally elongated carbon electrodes can be operated at high current when constructed with a thin outer shell and special core material **5**, such as shown in Figs. 3 and 4, or at low current when constructed of solid carbon with small stabilizing cores **6** as shown in Figs. 1 and 2, made of ground carbon formed into a mastic. The solid carbon of the positive electrodes has the same composition as is found in commercially available conventional carbons. The cored variety may be made by cutting slots in solid blanks or molded in the desired hollow form. The core material **6** is made of ground carbon and may contain an alkali salt in small amounts to which water is added to form a mastic. The cored electrodes are the easiest to operate. Special core materials with a thin shell may be composed in many different ways depending on the type of spectral characteristic desired. For example, cores **5** of positive electrodes giving a bluish-white light would contain salts of the metals of the cerium group, such as cerium oxide and cerium fluoride; for a more reddish light, iron or strontium may be used. The particular composition of the cores is well understood in the art and forms no part of the present invention other than that such cores are used in the horizontally elongated carbon electrodes of the present invention.

Figs. 5 and 6 show circuit arrangements which may be used for the arc sources made in accordance with the instant invention. The plural negative electrodes **7** in Fig. 5 may be operated to ignite the horizontally elongated positive carbon electrode **8** with separate ballasts or resistors **9** for each negative electrode or a single ballast **11**, as in Fig. 6, for both negative electrodes. In the circuit arrangement of Fig. 5, the total current flow from the direct current source **12** divides evenly between the dual negative electrodes **7** so they will operate simultaneously. The current division may vary slightly due to arc conditions. If one negative electrode fails to function, the current in the remaining negative electrode path will not increase. It is possible to modify the source **12** so that the voltage is alternately applied to each electrode so that the negative electrodes **7** will alternate in operation. The circuit arrangement of Fig. 6, including direct current source **12'**, permits such alternate operation of negative electrodes **13** to ignite the positive electrode **20**, which may be rectangular rather than tapered as shown, by the use of magnetic fields produced by current flow in the coils **10, 10'** which causes the arc to alternate between the negative electrodes **13**. While direct current sources have been discussed and shown in Figs. 5 and 6, it is possible to use alternating current sources to energize the arc source. The alternate operation as in Fig. 6 results from alternating increase in current flow in each of the coils **10, 10'** due to the reduction in resistance in each negative electrode path when the arc is struck causing greater current flow in the corresponding magnetic circuit which in turn repels the arc and blows it to the other negative electrode which then increases the current in its corresponding magnetic circuit and reverses the cycle. The arc is thus caused to alternate between each negative electrode and the positive electrode.

Photometric measurements were made to determine the distribution of intensity per unit area in the visible and the near infrared spectrum range. Tungsten ribbon operating at a color temperature of 2870 degrees K. was used as a reference. Longitudinal brightness of a horizontally elongated solid carbon electrode 32 mm. x 6 mm. operating with dual electrodes carrying a total current of 140 amperes was 180 candles/sq. mm. or 25 times brighter than tungsten ribbon operating at a color temperature of 2870 degrees K., 14 times brighter than tungsten wire operating at a color temperature of 3100 degrees K., 9 times brighter than tungsten wire operating at a color temperature of 3300 degrees K. and better than 3 times brighter than tungsten wire melting at a color temperature of 3817 degrees K.

A water-cooled high intensity 32 mm. x 6 mm. cored horizontally elongated positive carbon electrode showed a brightness of 1000 candles/sq. mm. over a 16 mm. longitudinal scan when operated at 240 amperes with a single negative electrode. A longitudinal brightness of 600 candles/sq. mm. was obtained at the center of this electrode with dual negatives operating at 140 amperes. The brightness tapered off on either side of the center to about 200 candles/sq. mm. a few mm. from each end. By proper negative electrode angle adjustment uniform or irregular longitudinal brightness distributions may be obtained.

The infrared intensity per unit area of a 32 mm. x 6 mm. solid horizontally elongated carbon electrode operat-

ing with dual negative electrodes and a total current of 120 amperes was 23 times greater than that of the tungsten ribbon operating at a color temperature of 2870 degrees K. Although a cored high intensity water-cooled elongated electrode exhibited an infrared intensity per unit area 33 times greater than that of the tungsten ribbon operating as above, a disproportionate increase in brightness was observed which would present filter problems in application.

Power consumption varies over a wide range for the arcs. The lowest power necessary to completely ignite the end of a 32 mm. wide positive carbon was 1.8 kw. while the highest power employed was 20.8 kw.

Reference is now made to Figs. 7–12 which illustrate apparatus permitting both vertical and horizontal angle adjustment of negative electrodes relative to the longitudinal axis of the positive carbon essential to control the burning of the positive electrode when using horizontally elongated solid or cored carbon electrodes. Each of the negative electrodes **14** are releasably secured in a bore **15** of block **16** by a thumbscrew **17**. The block **16** engages a horizontal sliding bearing **18** in the vertical support **19**. A horizontal slot **21** extends substantially the length of the support **19** to permit radial movement of block **16** which is retained in the horizontal sliding bearing **18** by a thumbscrew **22**. The vertical support **19** is mounted for sliding motion along each of the split flat ring segments **23** by a bracket **24** provided with a thumbscrew **25** for locking the position of the negative electrode at selected angles with respect to the longitudinal axis of the horizontally elongated positive carbon electrode **26**. A spring **27** extending from the thumbscrew **22** to the bracket **24** retains the block **16** against the adjustable stop **28** also carried in the bracket **24**. A pointer **29** which cooperates with the degree markings **30** on the split ring segments **23**, is secured to the block **16** for indicating the degree setting of the electrode on the ring segments **23**. The bell-crank lever having arms **31** and **32** is eccentrically secured to the vertical support **19** and has one arm **32** which contacts the block **16**. It is evident that when it is desired to strike the arc the arm **31** is pushed down which causes the block **16** to be moved forward toward the positive electrode and when the arc is struck the arm **31** is released and the block **16** is drawn back by the spring **27** to a position determined by the setting of the adjustable stop **28**. The arm **31** must be insulated for safety when it is hand operated. A negative electrode holder such as described above is used for each negative electrode and as shown in Fig. 7 for dual negative electrodes, one holder is mounted on each of the two segments **23** of the split flat ring. These segments **23** are mounted on the angle bracket **33** and insulated therefrom as at **34**. The angle bracket **33** is in turn supported by the vertical arcuate arms **35** attached to a sleeve **36** which may be adjusted vertically by means of adjusting screw **37** on a suitable standard or support **38**. Vertical adjustment of the assembly including the angle bracket **33**, split ring segments **23** and negative electrodes **14** and the holders therefor, previously described, is accomplished by means of slides **39** which ride on the arms **35**. The slides **39** may be secured in fixed position on the arms **35** by clamping bolts **41**. The angle bracket **33** which supports the negative electrode holder assembly is carried by a shaft **42** extending between the slides **39** by means of U-bolts **43** passing through the angle bracket **33**. The ends of the shaft **42** are secured to the slides **39** in any convenient manner. This construction permits the negative electrodes **14** to be adjusted to various vertical angles relative to the horizontally elongated carbon electrode **26**. The positive electrode **26** is supported by the structure shown generally at **44** which may include a water-cooled or other type head. It should be understood that certain applications may require a wide range of horizontal angle and vertical angle adjustments necessitating the use of a structure as described, while other applications may only require one specific setting of the vertical and horizontal angle for which an appropriate structure may be devised. Further, other variations in the structure, to permit varying the horizontal and vertical angles, may be made without departing from the basic teachings of the instant invention.

Figs. 13–16 show another form of negative electrode holder which is designed to advance or retract the electrode **45** by motor driven means. The motor drive is connected to the mechanism shown generally by **46** for advancing or retracting the negative carbon electrode **45** through a flexible or rigid shaft at **47**. This mechanism **46**, except for the additional structure shown in Fig. 15, is a standard commercially available item and will therefore not be described in detail herein. The additional structure shown in Fig. 15 includes a base block **48** of suitable electrically conductive material having a slot **49** slightly larger than the dimensions of the split ring segments **23** so that the base block **48** may be moved freely along the split ring segments **23**. A thumbscrew **51** permits clamping the base block **48** in a position along the split ring segments **23** depending upon the horizontal angle of the negative electrode desired relative to the positive horizontally elongated carbon electrode. A support block **52** of suitable electrically conductive material is mounted on the base block **48** by a wing nut and bolt as at **53** to permit rotating the support block **52** on the base block **48** for horizontal angular adjustment of the negative electrode **45**. The mechanism shown generally by **46** is carried by a stud **54** threaded at one end and having a reduced portion **55** passing through the support block **52** so that when the mechanism **46** is bolted to the support block **52** it may be freely rotated through a vertical angle which is governed by the physical design of the components. The stud **54** has a groove **56** for retaining one end of a spring **57**, the other end of which is secured to a bolt **58** secured in an arm **59** of the holder mechanism **46**. The arm **59** is integral with the electrode clamp **61** through which electrical energy is conducted to the electrode **45** from the conductor **62** which is connected to a terminal, not shown, located in the aperture **60** in support block **52** and which in turn may be connected to a source of electrical energy, not shown. The outer vertical face **63** of the base block **48** bears index marks **64** which cooperate with a single index line **65** on the support block **52** for measuring horizontal angular adjustment of the electrode **45** relative to the positive electrode, not shown. The degree marks **30** on the split ring segments **23** are the angles which the negative electrode **45** makes with the longitudinal axis of the positive electrode, not shown in Figs. 13–16, while the base block **48** and support block **52** combination also permit the negative electrode **45** to be rotated about the bolt **53** to change the horizontal angle, as above, arc length and foot-point along the positive electrode, not shown. Using the degree markings **30** on the split ring segments **23** the locus of the center of rotation, for each length of negative carbon electrode, is a relatively fixed point on the longitudinal axis of the positive horizontally elongated carbon electrode, or fixed foot point on the positive electrode, while in the base block and support block combination the center of rotation is at the bolt **53**. The structure shown in Fig. 15 therefore is an alternative when a stationary support other than the split-ring segments is used, and has the advantage of permitting changes in arc length and foot point on the positive carbon as well as horizontal and vertical angles measured as heretofore described.

Having thus described my invention, what I claim as new and wish to secure by Letters Patent is:

1. A carbon arc device comprising in combination a positive electrode having an elongated cross-section, means for supporting said positive electrode with the length thereof normal to an exposed cross-sectional area,

a plurality of negative electrodes, holder means for each said negative electrode for independently supporting each of said plurality of negative electrodes to project towards the exposed cross-sectional area of said positive electrode with the longitudinal axis of each said negative electrode angularly disposed relative to the longitudinal axis of said positive electrode, semicircular segmented mounting means slidably carrying said holder means thereon, arcuate support members extending normal to said semicircular segmented mounting means and connected thereto for slidably adjusting said semicircular segmented mounting means along the length of said arcuate support members for relative vertical angular adjustment therewith, a base for supporting said arcuate support members, and means for electrically energizing said positive and negative electrodes whereby an electrical arc may be established.

2. A carbon arc device as recited in claim 1 wherein said holder means for each said negative electrode comprises an angle bracket releasably engaging said semicircular segmented mounting means, a first support member carried by said angle bracket including a recess extending horizontally and communicating with a horizontal slot, a second support member slidably disposed in said recess and secured in said slot for horizontal sliding movement along said recess within the limits of said slot, a bore in said second support member for receiving an electrode therein, a lever rotatably secured to said first support and engaging said second slidably disposed member for imparting movement to said second support member along said recess, biasing means opposing the forward motion of said second support member and adjustable stop means mounted on said angle bracket and engaging said second slidably disposed member.

3. A carbon arc device as recited in claim 1 wherein said holder means for each said negative electrode comprises motor driven means for controlling the movement of said negative electrode, a base member having an opening therein for receiving said semicircular segmented mounting means for sliding engagement therewith, a support member carried by said base member for relative rotation about an axis normal to said base member, stud means securing said motor driven holder to said support member providing vertical angular adjustment of said motor driven holder and horizontal angular adjustment about said vertical axis and biasing means connected between said stud means and a jaw engaging said negative electrode on said motor driven holder to impart a clamping action on said negative electrode and electrical conductor means connected between said support member and said jaw.

4. A carbon arc device as recited in claim 1 wherein means for energizing said positive and negative electrodes comprises a source of electrical energy connected

to said positive and negative electrodes, said negative electrodes being connected in parallel to said energizing source and each path of said parallel connection including electrical ballast means for limiting the current therein.

5. A carbon arc device as recited in claim 1 wherein said means for energizing said positive and negative electrodes comprises a source of electrical energy, a plurality of serially connected electrically conducting paths, each said conducting path including a negative electrode and electro-magnetically actuated arc control means, and electrical ballast means interconnecting said plural conducting paths and said source of electrical energy for limiting the current in said conducting paths.

6. A carbon arc device comprising a common electrode having an elongated exposed cross sectional area substantially normal to its longitudinal axis, means for supporting said common electrode, a plurality of elongated other electrodes and means for intermittently moving and securing said other electrodes with their longitudinal axes in the plane determined by the longitudinal axis of said common electrode and the major axis of said cross sectional area and with their longitudinal axes directed toward said cross sectional area whereby operation of said arc device produces an elongated light source.

7. A carbon arc device comprising a common electrode having an exposed elongated cross sectional area substantially normal to its longitudinal axis, means for supporting said common electrode, a plurality of elongated other electrodes and means mounting said other electrodes for simultaneous horizontal and vertical arcuate adjustment when the device is oriented with said longitudinal axis and the major axis of said cross sectional area both horizontally disposed with said other electrodes continually pointed toward said cross sectional area at a predetermined distance from said area.

8. The carbon arc device of claim 7 wherein said other electrodes are connected to said means mounting said other electrodes by spring biased positioning means for permitting independent longitudinal movement of each said other electrode toward said common electrode and spring driven return of each said electrode to a predetermined equilibrium position.

References Cited in the file of this patent

UNITED STATES PATENTS

572,312	Price	Dec. 1, 1896
628,782	Faulkner	July 11, 1899
881,518	Wilson	Mar. 10, 1908
1,007,151	Speiden	Oct. 31, 1911
1,032,247	Smith	July 9, 1912
1,871,699	Jeppsson	Aug. 16, 1932
2,156,360	Stahn	May 2, 1939