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OSCILLATION GENERATOR OF THE ARC TYPE

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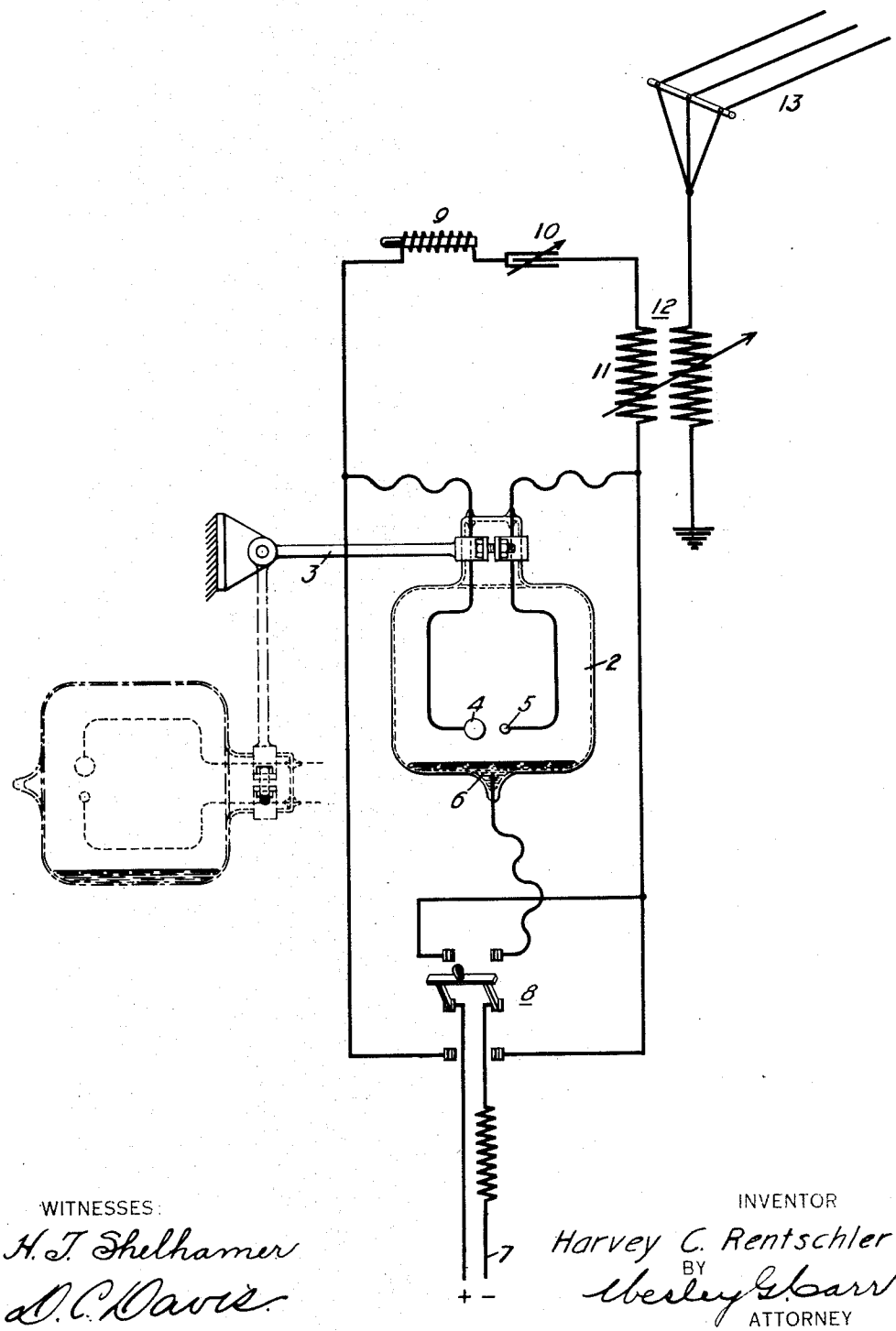

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UNITED STATES PATENT OFFICE.

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OSCILLATION GENERATOR OF THE ARC TYPE.

Application filed November 9, 1918. Serial No. 261,910.

To all whom it may concern:

Be it known that I, HARVEY C. RENTSCHLER, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Oscillation Generators of the Arc Type, of which the following is a specification.

My invention relates to alternating-current generators of the oscillation-arc type, and it has for its object to provide apparatus of the character designated that shall be simple and inexpensive in construction and highly effective in operation.

The single figure of the accompanying drawing is a diagrammatic view of an oscillator embodying a preferred form of my invention, together with the associated circuits.

Oscillators of the Duddell and Poulsen type are well known, wherein a vaporizing arc is maintained between carbon electrodes or between a copper electrode and a carbon electrode in an atmosphere of hydro-carbon vapor, the arc being shunted by a resonant circuit and being continuously blown out by magnetic means.

Apparatus of this character is highly effective in operation but, for certain classes of application, as for small portable outfits, it is somewhat cumbersome and expensive.

I find that, if a discharge is initiated between refractory metal electrodes, such, for example, as tungsten, within atmospheres of special character, it will cause satisfactory oscillations without the necessity for artificial cooling and without the necessity of a magnetic blowout. While some of the claims and descriptive mater in the present application refer to the discharge of an arc, an attempt will also be made to point out the invention with respect to a possible theory of operation involving certain distinctions between the various types of arcs, which will now be explained. In the arc, as originally understood, the luminous discharge was known to depend upon the character of the disintegrated or vaporized electrode material. This was amply proved and made use of in spectrum analysis. The electrical and illuminating properties of the arc of the present invention are of an entirely different character. The disintegration or evaporation of the electrode material is of secondary importance, so that the spectrum lines of the glow discharge or glowing arc, as the discharge of the present invention may be rightly called, are substantially due only to the properties of the atmosphere artificially interposed. The properties, electrical and otherwise, of the electrode material at high incandescence act, in this case, as mere masking effects only of superposable character. The two types of discharge, viz, the old vaporizing arc and the new glowing arc, for scientific and engineering purposes are, therefore, to be very carefully distinguished, one from the other. I have found the following facts concerning arcs between refractory electrodes in a mixture of gas with mercury vapor. The mercury vapor in all cases was present only due to the heat from the electrodes vaporizing some of the mercury. The mercury was originally used for simplicity of starting, but the following peculiarities were found and form the basis for my application.

When the gas used was helium with mercury vapor, the arc in all cases was diffuse between the electrodes spreading over both anode and cathode, and the voltage-current characteristic was rather flat.

When using hydrogen with mercury vapor, the arc could very easily be made to take the form of a fine stream of luminous discharge between the electrodes, concentrating on both the anode and cathode. This only happened with any degree of ease when the pressure of the hydrogen was sufficiently high and I found that with a hydrogen pressure below 10 cms. it was rather difficult to bring about the effect. Also, that the amount of mercury vapor present was somewhat critical. For example, if the bulb was tilted so that the arc was very close to the mercury, the fine-

line discharge could not be brought about and again, if no mercury vapor was present, it was again very difficult to produce this fine stream discharge. The arc voltage-current characteristic is very much steeper when operating with this fine stream effect than when operating otherwise and also very much steeper than with any other gases tried. The oscillating arc is much easier to operate, high frequencies are much more readily produced under this condition and unless the fine-stream discharge was present, very high frequencies were impossible. Other details of my invention will be hereinafter more fully set forth.

Referring to the drawing for a more detailed understanding of my invention, I show a closed container at 2, formed of glass or other heat-resistant insulating material, this container being mounted for movement into either a vertical or a horizontal position, as by being attached to the end of a pivoted arm 3. For large-capacity apparatus, a metal container may be employed, suitable insulation being provided for the electrodes. The container 2 is provided with a relatively large metallic electrode 4 and with a relatively small metallic electrode 5 mounted in close proximity thereto, these electrodes being formed preferably of tungsten, although other highly refractory metals, such as molybdenum, zirconium or chromium may be substituted therefor. The electrode 5 should preferably comprise a head of refractory material carried on the end of a wire of smaller cross-section. The container 2 is further provided with a starting electrode 6, formed preferably of mercury.

A source of unidirectional current is connected through suitable mains 7 and a double-throw switch 8 for the energization of the apparatus. When the switch 8 is thrown to its upward or starting position, the small electrode 5 is connected to the positive terminal of the source, and the auxiliary electrode 6 is connected to the negative terminal thereof. When the switch 8 is thrown to the down or running position, the larger electrode 4 is connected to the positive side of the circuit and the smaller electrode 5 is connected to the negative side thereof.

A resonant circuit, embodying an inductive reactor 9 and a capacitive reactor 10, is connected across the leads of the electrodes 4 and 5 and further includes the primary winding 11 of a transformer 12, the secondary of which is connected to a consumption circuit, such as an antenna 13; although the arc may be inserted directly in the antenna circuit, as is usual in the art, if desired.

Having thus described the arrangement of apparatus embodying my invention, the operation thereof is as follows. The tube 2 is first swung into the upright or full-line position and the switch 8 is thrown to its upper position. The tube is then agitated until the mercury of the electrode 6 splashes into contact with the electrode 5, initiating a small mercury arc. This arc is permitted to run until the electrode 5 is heated to incandescence, whereupon the switch 8 is thrown to its downward position, and the tube is swung to the horizontal or dotted-line position. The incandescent electrode 5 initially ionizes the gap between the electrodes 4 and 5 and a direct-current arc flows between these electrodes upon throwing the switch 8, the large electrode 4 being the anode. When running in this manner, the small electrode, operating as the cathode, remains at incandescence, whereas the anode 4, because of its relatively large size, remains comparatively cool. I have shown my tube 2 mounted for movement into either a vertical or a horizontal position so that the mercury may be brought near enough to the electrode 5 to be easily splashed thereagainst for starting but may be moved out of the immediate vicinity of the arc between the electrodes 4—5 to vary the relative proportion of mercury vapor with respect to the hydrogen gas present in the tube, by preventing excessive vaporization of the mercury during normal operation.

It is now found that, by proper adjustment of the resonant circuit, oscillations of any desired frequency may be produced, as in the ordinary Duddell or Poulsen arc, these oscillations being transferred to the antenna circuit.

Various gases may be placed within the container 2 but I find that very good results may be obtained by the use of hydrogen gas considerably under atmospheric pressure as, for example, with an absolute pressure of 40 centimeters of mercury. It should be distinctly understood, however, that I am not restricted to hydrogen as a filling material, as satisfactory results may be secured for audible frequencies with some other gases such, for example, as helium, although the latter has not been found satisfactory for radio frequencies. Furthermore, great latitude in the absolute pressure within the container is possible.

It is well known that an arc starts with considerable difficulty in a hydrogen atmosphere, and particular attention is directed to the fact that, by starting with an auxiliary mercury vapor arc, as shown, the hydrogen gas is temporarily displaced in the neighborhood of the fixed electrodes, thus permitting a far more ready start than would otherwise be possible. The characteristic of an arc of good oscillating qualities is that, as far as possible, it shall occur as a fine discharge stream. Since hydrogen,

by reason of its being diatomic, provides a medium for inelastic encounters, any electrons taking devious paths in passing from electrode to electrode will experience a considerable slowing up when meeting with the hydrogen, and, therefore, act as ineffectual carriers of the electric discharge. The electrons occurring in the straight-line path between electrodes will, from this point of view, furnish by far the major portion of the current flow. It is this observation, moreover, that explains why gases providing elastic as against inelastic encounters would not give the finer discharge stream best found with hydrogen.

In another respect, apparatus constructed in accordance with my invention differs in its operating characteristics from the Poulsen and Duddell vaporizing arcs. As is pointed out by Zenneck on pages 233 to 239, inclusive, of "Wireless telegraphy" (Seelig translation, 1915), the arc generators of the prior art have three conditions of operation, namely, wherein the supply current exceeds the instantaneous value of the output current at all times; wherein the instantaneous value of the output current at times exceeds the input current without relighting or reverse current in the arc; and similar action with relighting in the arc.

Obviously, operation of the first-mentioned character is desirable, as it involves current flow at all times through the arc in the same direction, thus giving rise to a persistent arc. Zenneck states that operation of this type is of no practical importance because of the low energy that may be developed thereby.

In extension or possible contradiction of these conclusions of Zenneck, I find that operation of the first type is entirely feasible with apparatus of the character above set forth. I am able to transform ample amounts of energy for commercial requirements while maintaining the maximum oscillation current below the supply current, whereby an extremely persistent glowing arc is produced, since the current therein never reverses in direction. While I do not wish to be confined to any specific theory of operation in explanation of these novel results, they appear to flow partly from the nature of the electrodes employed and partly from the nature of the atmosphere.

I have shown the electrodes 4 and 5 of dissimilar size in order to clearly visualize the fact that they should preferably attain different operating temperatures, but, obviously, these electrodes might well have the same superficial dimensions, if provided with dissimilar heat-radiating means, and attain the identical result. Furthermore, satisfactory operation may be secured with the two electrodes at the same temperature.

It is usually assumed that inductance and resistance should be inserted in the supply leads of a Poulsen arc generator for proper operation thereof but I have secured successful operation with the use of only a small protective resistor in the supply lead, inductance either being nonessential or being supplied in proper measure by the inherent properties of the supply leads.

While I have shown my invention in but a single form, it will be obvious to those skilled in the art that it is susceptible of various minor changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or are specifically set forth in the appended claims.

I claim as my invention:

1. An oscillator comprising an arc between solid electrodes in an atmosphere of a mixture of hydrogen and mercury vapor at a relatively high pressure, whereby a fine-stream discharge is secured.

2. An oscillator comprising an envelope containing hydrogen at a substantial pressure and a quantity of mercury vapor, a pair of solid electrodes therein and means for impressing current therebetween, whereby a fine-stream discharge is obtained.

3. A high-frequency electrical oscillator comprising an evacuated sealed envelope containing refractory, closely-spaced electrodes connected to a source of electrical energy, a mixture of hydrogen and mercury vapor in said envelope whereby a fine-line discharge having a relatively-steep voltage-current characteristic occurs between said electrodes and a resonant circuit associated with said electrodes.

4. A high-frequency electrical oscillator comprising an evacuated sealed envelope containing refractory, closely-spaced electrodes connected to a source of direct current, hydrogen at a substantial pressure in said envelope, a quantity of mercury therein, means for starting an arc between the mercury and an electrode and means for transferring the arc from the mercury to the other electrode, whereby a fine-stream discharge is secured therebetween.

5. A high-frequency electrical oscillator comprising an evacuated sealed envelope containing closely-spaced refractory electrodes in an atmosphere of hydrogen at a pressure of about 40 centimenters of mercury, a quantity of mercury therein, means for starting an arc with the mercury as the cathode and an electrode as the anode and means for transferring the arc from the mercury to the other electrode with a change of the first electrode from an anode to a cathode.

6. A high-frequency electrical oscillator comprising an evacuated sealed envelope enclosing closely-spaced refractory electrodes

in an atmosphere of hydrogen at a substantial pressure, a quantity of mercury in said envelope, means for starting an arc between the mercury and an electrode, means for transferring the arc from the mercury to the other electrode, means for moving the envelope to change the distance of the mercury from the arc and a resonant circuit in shunt with the arc.

In testimony whereof, I have hereunto subscribed my name this 1st day of Nov., 1918.

HARVEY C. RENTSCHLER.