

Aug. 27, 1940.

K. PFEILSTICKER

2,212,950

METHOD AND APPARATUS FOR SPECTRUM EXCITATION

Filed Nov. 17, 1938

2 Sheets-Sheet 1

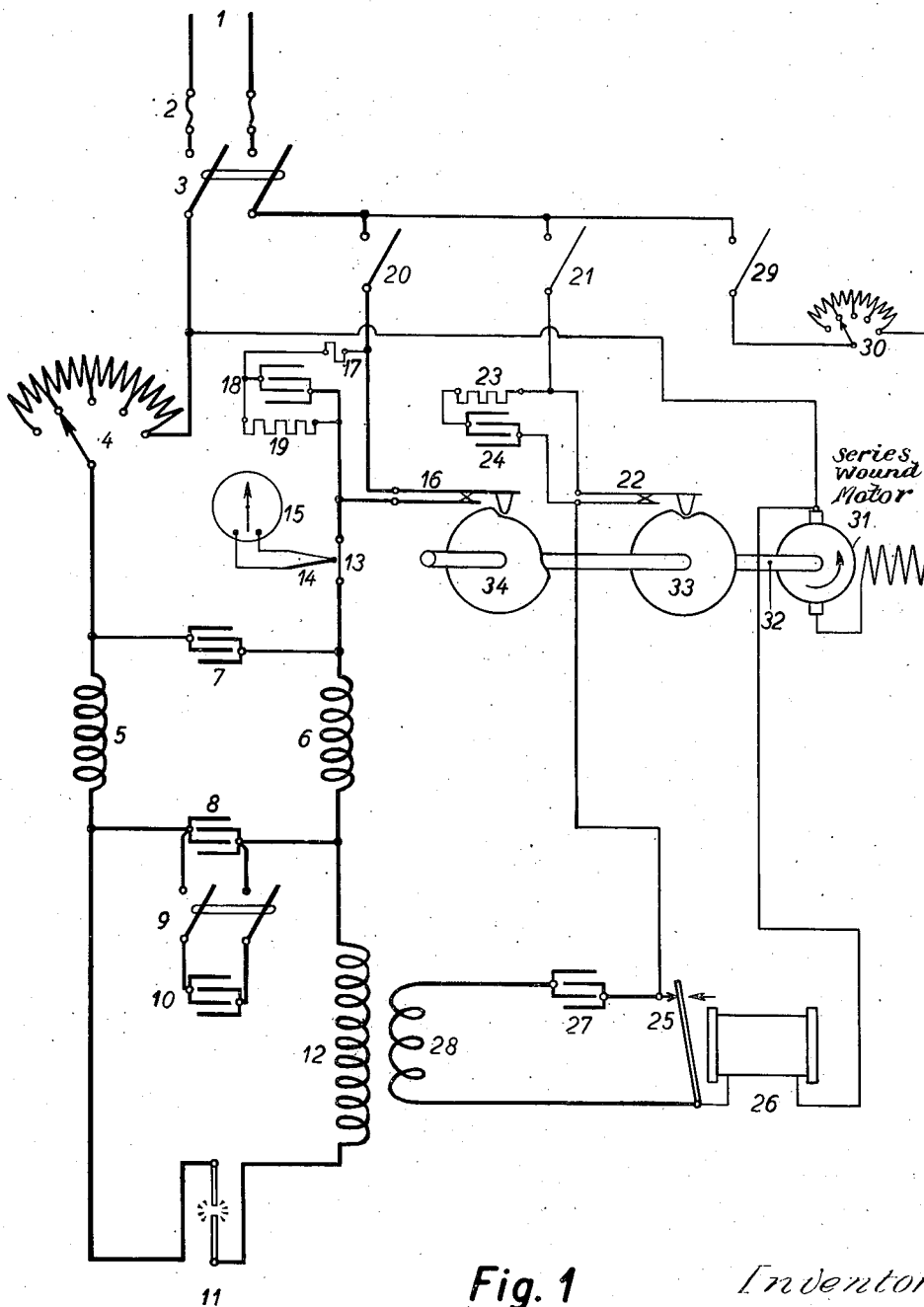


Fig. 1

Inventor:

Karl Pfeilsticker

By
Williams, Bradbury, McCobb & Hunkle
Attys.

Aug. 27, 1940.

K. PFEILSTICKER

2,212,950

METHOD AND APPARATUS FOR SPECTRUM EXCITATION

Filed Nov. 17, 1938

2 Sheets-Sheet 2

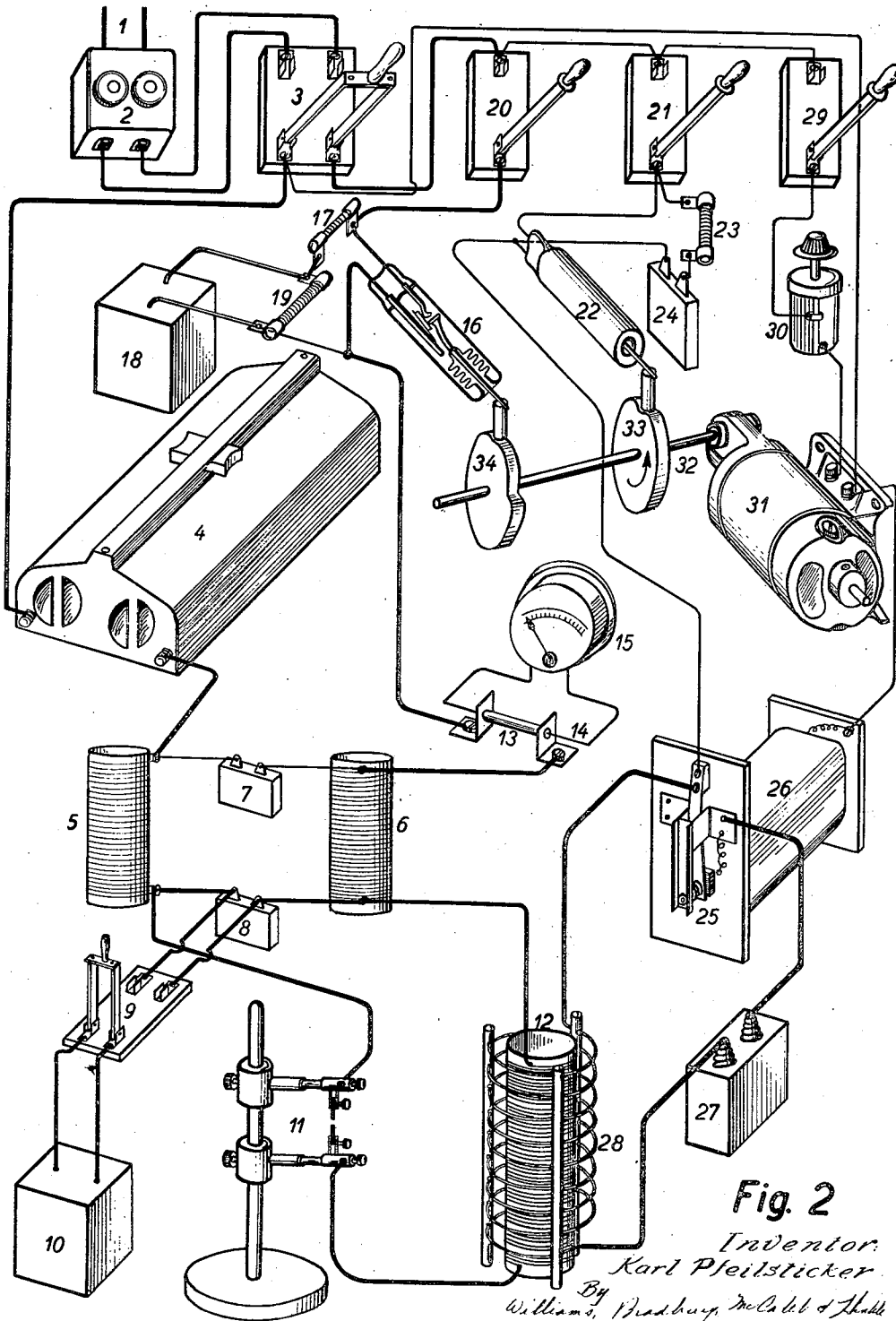


Fig. 2

Inventor:
Karl Pfeilsticker
By
Williams, Bradbury, McCall & Shultz
Attys

UNITED STATES PATENT OFFICE

2,212,950

METHOD AND APPARATUS FOR SPECTRUM EXCITATION

Karl Pfeilsticker, Stuttgart, Germany, assignor to
W. C. Heraeus G. m. b. H., Hanau-on-the-Main,
Germany, a corporation of Germany

Application November 17, 1938, Serial No. 240,902
In Germany November 24, 1937

7 Claims. (Cl. 176—12)

The invention relates to the art of spectrum excitation. Various modes of excitation are in use, among which are the arc and high tension spark. The arc is far more sensitive and provides a clearer spectrum than the high tension spark, but it has some disadvantages especially an excessive development of heat.

An object of this invention is to provide a method and apparatus, particularly suited for spectrum analysis, by means of which those difficulties which occur in using the arc for excitation of spectra may be removed.

A further object is to provide for striking the arc in such a manner that a "flash-over" of the arc by mechanical means through touching of the electrode points and the disadvantages connected therewith are avoided.

Briefly stated, the invention achieves these objects by superimposing on an electric current used for the spectrum excitation a current of higher potential which is able to strike the arc. This ignition current may have an intensity of from 0.01 amp. to 3 amps., suitable values being 0.1–0.2 amp., and in general produces between the two electrodes of the arc a potential of from 1000 to 20,000 volts, a suitable value being about 10,000 volts. The spectrum excitation current may be applied intermittently in order to avoid excessive heating of the electrodes, while the superimposed ignition current may be applied continuously during the whole operating period or intermittently in synchronism with the spectrum excitation current. When working with direct current the ignition current need only be applied for a brief moment in order to strike the arc. With alternating current, however, the ignition current should be applied during the whole of the period during which the arc is to persist, since otherwise the arc would be prematurely extinguished.

In order that the invention may be more fully explained, reference is now made to the accompanying drawings and the following detailed description thereof. In the drawings, Fig. 1 shows a circuit diagram and Fig. 2 a layout in perspective, corresponding to Fig. 1, of an apparatus for performing the method of the invention. It is emphasized that the invention is not limited to the embodiment shown since, as will be apparent to those skilled in the art, the mode of performance of the invention is susceptible of many variations, a few of which will be indicated hereinafter.

The embodiment illustrated is designed for working from a direct current supply; the modifi-

cations necessary for using alternating current are self-evident.

Referring to the drawings, there are essentially three circuits to be distinguished; the arc current circuit, the ignition current circuit, and a motor circuit. From the supply 1 the current passes over the fuses 2 to the main switch 3 and from there through the switches 20, 21, 29 to the three circuits. In the arc current circuit there is at 11 a pair of arc electrodes conveniently mounted on a stand and arranged so as to be adjustable, according to customary practice. Between the electrodes is placed in customary manner the material the spectrum of which, especially for analytical purposes, is to be examined. An adjustable resistance 4, for example of 175 ohms, is included in this circuit. The arc current may be adjusted at about 1 to 10 amps.

The electrical energy for the ignition current circuit is obtained, in the arrangement shown, through the secondary 12 of a Tesla transformer included in the arc current circuit. Instead of using the secondary of a Tesla transformer, other means such as the secondary of an ordinary inductor may be employed in order to provide at the arc electrodes a potential difference sufficient for striking the arc.

In order to apply the arc current intermittently an interrupter 16 is provided after the switch 20. This interrupter may consist of a vacuum switch (shown in section in Fig. 2) operated by the cam 34. For suppressing sparking at this switch, it is shunted by a large condenser 18 of 40 microfarads through a small damping resistance 17 of 0.8 ohm. For automatically discharging the condenser 18 it is shunted by a resistance 19 of 250 ohms.

The superimposed ignition current is led partly through the condenser 8 of e. g. 0.1 microfarad which bridges the arc gap 11 and the secondary 12 of the Tesla transformer. In order to generate spark-like discharges if required, a switch 9 is provided for connecting in parallel with the condenser 8 a large condenser 10 of 1–1000 microfarads, a suitable value being 100 microfarads. The condenser 10 is then charged from the main supply and at the moment of high frequency ignition gives a surging discharge across the arc gap 11, the secondary 12 of the Tesla transformer acting as a quencher.

Several Tesla transformers may be provided having their primaries arranged in parallel and their secondaries in series in order to obtain higher ignition potentials with minimum self-induction in the secondary circuit. This is im-

portant for condenser discharge with the condenser 10 owing to the slight quenching.

The lead and return paths of the spectrum excitation current include choke coils 5, 6 (one in each path) of about 240,000 cm. which are preferably bridged by a condenser 7 of 0.5 microfarad, as well as by the condenser 8. The function of these choke coils is to block the high frequency from the secondary 12 and prevent it reaching the mains 1, while the bridging condensers (7 and especially 8) provide a free path for the high frequency to the arc gap 11.

For controlling the current intensity a thermocouple meter is provided in this current circuit, consisting of a constantan heating tubule 13 in which a thermo-element 14 is stretched, the thermoelectric potential of which is indicated by the galvanometer 15. This galvanometer is calibrated in amperes so that the switching time ratio determined by the peripheral length of the cam 34 is taken into account.

In the embodiment shown the ignition potential is supplied to the arc circuit through a Tesla transformer; the ignition circuit being controlled by the switch 21. An arrangement is also shown for intermittently applying the current. This is effected by means of the cam 33 which operates a vacuum switch 22 which, for suppressing switch sparking in the strong inductive circuit, is shunted with a condenser 24 of e. g. 0.25 microfarad and a resistance 23 of e. g. 30 ohms in series. From the vacuum switch 22 this circuit leads to the high frequency generator which, in the example shown, is an automatic interrupter comprising an oscillatory contact 25 and a coil 26. The latter may consist of 3,200 turns of a 0.3 mm. stout copper wire and an iron core made up of transformer stampings of 13x13 mm. section. From this coil the current path returns to the other terminal of the main supply.

In parallel with the interrupter contact 25 is an oscillatory circuit consisting of a condenser 27 e. g. of 18,000 cm. and the primary 28 of the Tesla transformer. This oscillatory circuit 27, 28 may be considerably varied; the capacity may be from 1,600 cm. to 1 microfarad and the self-inductance from 1,000 cm. to 1 henry. The spring of the armature with the contact 25 produces, owing to automatic interruption, about 100 oscillations per sec. At each cycle with open contact 25 the condenser 27 is charged and with closed contact 25 the condenser is discharged through the primary 28 of the Tesla transformer as high frequency. The self-induction of the primary 28 of the Tesla transformer amounts for example to 10,600 cm. with 11 turns and that of the secondary 12 for example to 1,750,000 cm. with 194 turns. The oscillatory current in the circuit 25, 27, 28 when constantly switched in, that is by shorting the control switch 22, amounts to about 5 amps. The high frequency ignition current flowing through the secondary of the Tesla transformer under the same condition is of the order of 0.15 amp. The arc gap 11 of e. g. 5 mm. is thus efficiently bridged.

The Tesla transformer has a step-up ratio of from about 1:1 to 1:1000, a suitable value being 1:18. The coupling should not be too tight otherwise unwanted reaction occurs. The secondary is preferably in the form of two or more nested coils sufficiently spaced. As already mentioned, several Tesla transformers may also be used, the primaries being arranged in parallel and the secondaries in series.

The arrangement described for producing the

high frequency is merely one example. In place of this other known means may be used, such as the valve generator described by Findelsen. Also, a quenched spark generator may advantageously be used with an alternating current supply. Further ignition potential could be supplied directly through a capacitive coupling, which would then enable a high number (which is desirable) of secondary turns of suitably thin wire to be used since they are no longer traversed by the arc current. The condenser 8 can then be dispensed with, while the chokes 5, 6 are larger and can be adjusted by a shunt capacity to the wavelength of the ignition high frequency in order to block it from the main and to ensure the flash-over at the arc.

As shown the interruption of the arc and ignition circuits is effected by vacuum switches which are controlled by a small series-wound motor 31 which is connected to the main supply 1 through a regulating resistance 30 of e. g. 2,400 ohms. This motor 31 which may be of about 30 watts output drives the shaft 32 through a suitable drive such as a belt, gear wheels or a worm, of say 1:5 ratio. On the shaft 32 are mounted the disc cams 33, 34 which, in the example shown for direct current, have such configuration that firstly the cam 34 closes the arc current switch 16 whereupon almost immediately afterwards the ignition current switch 22 is operated by the cam 33 to switch the ignition current on and off. After a certain interval after a quarter revolution (in the arrangement shown) the arc current is again switched off by the switch 16. This cycle is repeated with each revolution of the shaft 32, the speed of which may be adjusted by means of the variable resistance 30. The shaft speed may for example be from 1 to 10 revolutions per sec. The cam 34 can be so designed that different circuit closing periods can be provided; for instance, instead of the quarter revolution shown in the diagram, about one-half or one-eighth revolution or less, or any intermediate value, may be chosen.

Instead of the interrupter mechanism shown, other arrangements known for this purpose may be used. Thus instead of the vacuum switches, other suitable switches such as mercury interrupters or mechanical switch elements may be used. Moreover, switching-off may be effected by quenching the arc by means of a shunt capacity, by extinguishing the arc with a gaseous medium, by magnetic or electromagnetic means, or by means of a Thyatron such as that described in *Elektrotechnische Zeitschrift*, 58th year, No. 24, June 17, 1937, page 671, published by Julius Springer, Berlin, Germany.

The new method of spectrum excitation shows a number of important technical improvements. Important advantages of the new disruptive arc compared with the hitherto known light arcs reside in the unobjectionable ignition, in the automatic passage of the arc, and in the fact that both electrodes are fixed. For working the new method an ordinary spark holder may be used. The new disruptive arm may also be used for the analysis of materials with which difficulties have hitherto been encountered, for example such metals as aluminium, also blood and serum and bodily organs such as the liver. Since the electrodes are no longer mechanically subject to shock there is no risk that the substance under analysis may be thrown down by the auxiliary electrode. Since the electrodes are fixed, the new arc, moreover, may without special difficulty be transferred to a closed space and used in another

atmosphere or under other pressure than in air. The new method of exciting spectra combines therefore the advantages of the disruptive arc with the numerous advantages of the spark.

I claim:

1. Apparatus for spectrum excitation by an electric arc, comprising a pair of arc electrodes, means for applying to said electrodes a current for exciting a spectrum, and means for applying to said electrodes a potential difference caused by a current of lower energy than that of the arc current for striking the arc.

2. Apparatus as defined in claim 1 in which said last-mentioned means include a Tesla transformer.

3. Apparatus for spectrum excitation by an electric arc, comprising a spectrum-exciting circuit including a pair of arc electrodes, and means for applying a spectrum-exciting current thereto, including a resistance for adjusting said current and a coil, and an arc ignition circuit including means for generating an oscillatory ignition current and means for applying said ignition current to said arc electrodes, said means last-mentioned including said coil and a condenser.

4. Apparatus as defined in claim 3 in which

said coil is the secondary of a Tesla transformer the primary of which is connected with means for generating high frequency oscillations.

5. Apparatus for spectrum excitation by an electric arc, comprising a spectrum-exciting circuit including a pair of arc electrodes, means for applying a spectrum-exciting current thereto, means for periodically interrupting said current, said first means including the secondary of a Tesla transformer, and an arc-ignition circuit including a high frequency oscillation generator, means for periodically interrupting said generator in synchronism with the interruptions of said spectrum-exciting current, and the primary of said transformer.

6. Apparatus as defined in claim 5 and comprising means in said spectrum-exciting circuit for blocking the passage of the high frequency ignition oscillations to the input of said circuit.

7. Apparatus as defined in claim 3 and comprising in addition to said condenser a large condenser of from 1 to 1000 microfarads and switching means for connecting said large condenser in parallel with said first-mentioned condenser at will.

KARL PFEILSTICKER.