United States Patent

Sörensen et al.

[15] **3,662,169**

[45] **May 9, 1972**

[54] APPARATUS FOR EXPOSING A WEB MATERIAL TO A CONTROLLABLE SPARK DISCHARGE

[72] Inventors: **Bent Sörensen; Frank Högfeldt,** Trittau, Germany

[73] Assignee: **Softal Elektronik GmbH,** Hamburg, Germany

[22] Filed: **Apr. 10, 1970**

[21] Appl. No.: **27,252**

[30] **Foreign Application Priority Data**

Apr. 10, 1969 Germany .....P 19 18 145.4

[52] **U.S. Cl.** .....**250/49.5 TC,** 317/262 R

[51] **Int. Cl.** **H01j 37/00,** G01n 23/00

[58] **Field of Search** .....204/312, 323; 250/49.5 GC, 250/49.5 TC; 317/262 R

[56] **References Cited**

UNITED STATES PATENTS

3,514,393	5/1970	Eisby	204/312
3,192,385	6/1965	Antokal	250/49.5

Primary Examiner—William F. Lindquist

Attorney—Roylance, Abrams, Kruger, Berdo and Kaul

[57] **ABSTRACT**

Apparatus for spark discharge treatment of a web of material wherein the discharge is continuous. A constant frequency oscillator drives the primary of a high-frequency power transformer which is closely coupled to the secondary of the transformer on a closed ferrite-core having low dispersion. The self-induction of the core is variable to keep the product of inductance and load impedance constant. The spark gap is connected to the transformer secondary. The inductance is chosen so that, with the capacitance of the spark gap and of the material web, the circuit is resonant at the operating frequency. The load on the oscillator is accordingly purely resistive.

4 Claims, 8 Drawing Figures

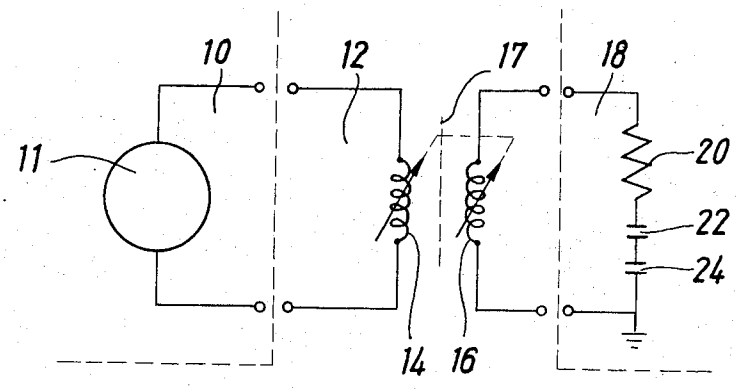


Fig. 1

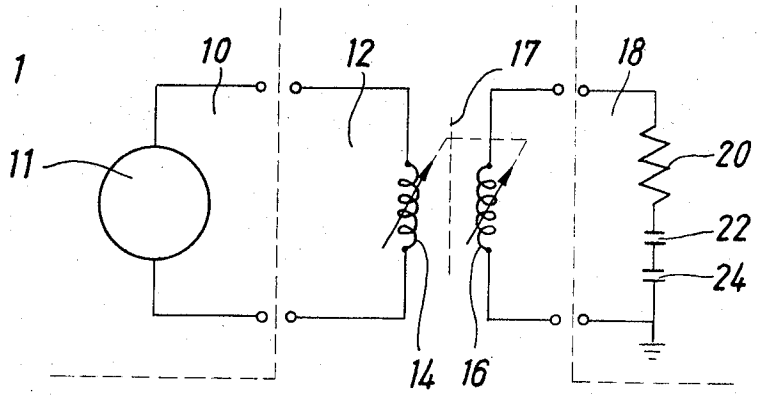


Fig. 2

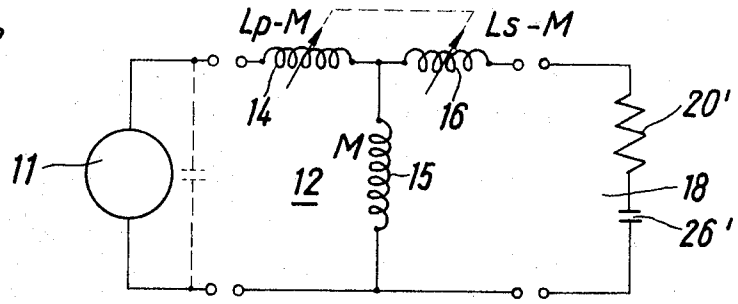


Fig. 3

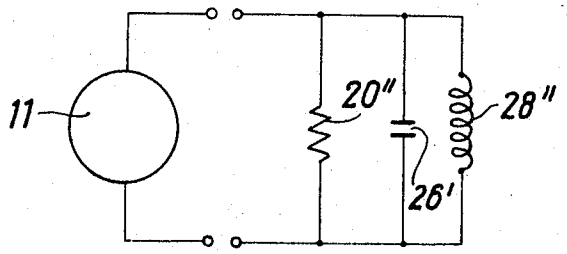


Fig. 4

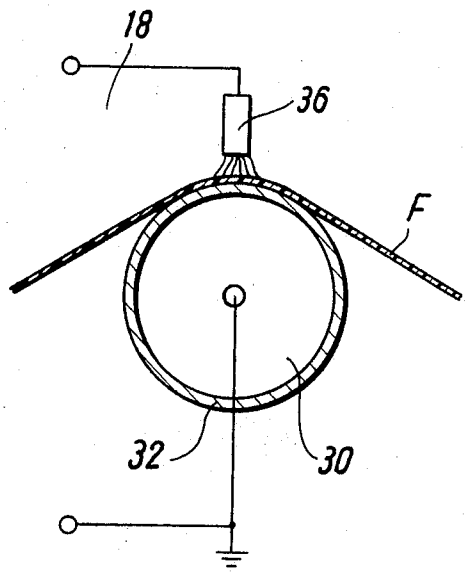


Fig. 5

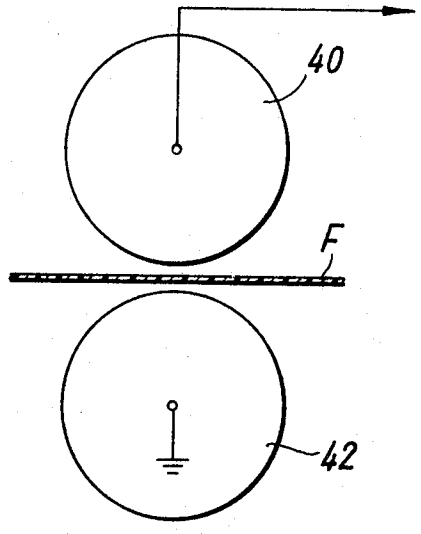


Fig. 6

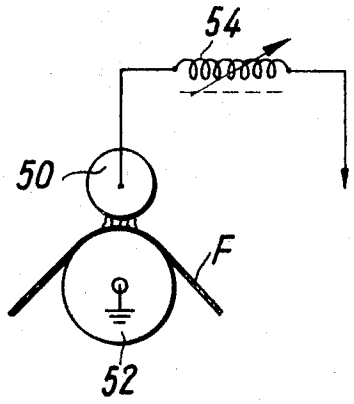


Fig. 7

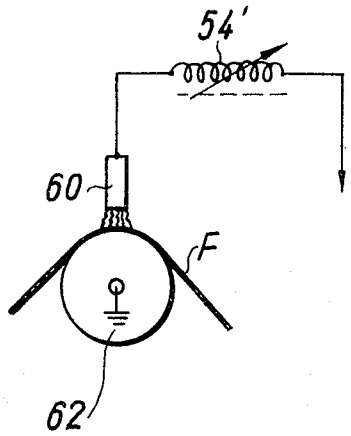
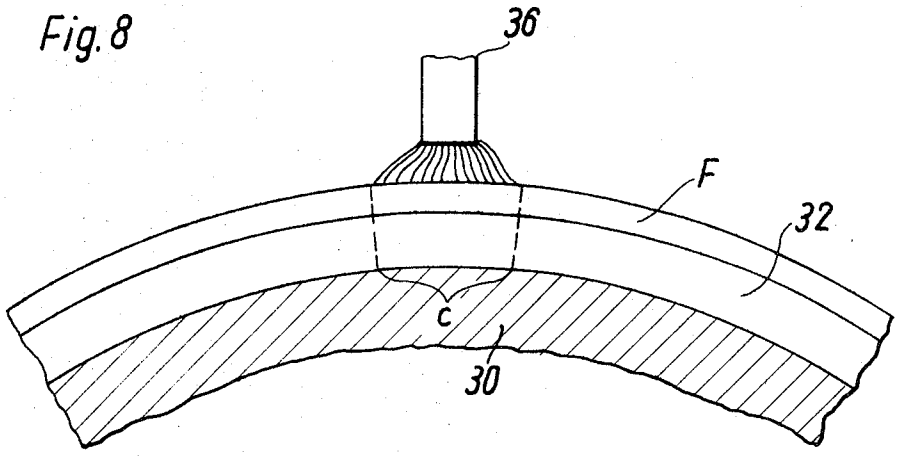


Fig. 8



APPARATUS FOR EXPOSING A WEB MATERIAL TO A CONTROLLABLE SPARK DISCHARGE

The invention relates to a device for the treatment of surfaces, especially for cleaning and improving the wettability of parts or strips made of synthetic resin, metal, paper or textiles, by means of high-frequency discharge, using a high-frequency generator which, is connected over a high-frequency power transformer to the treatment part formed by the electrodes and the part of strip which is to be treated.

Devices of this general type operate by the surface of an object or of a strip of synthetic resin, metal, paper or a textile fabric being treated with a spark discharge. Conventional devices often have the disadvantage that it is extremely difficult to obtain a constant discharge. Conventional applicances use, e.g., an oscillator with a continuously adjustable frequency for control of the end power output in order to make possible correct adjustment of the device. Furthermore there are known apparatuses which are operated by means of a spark generator. Many known devices have, among other things, the disadvantage that, as a result of the special design of the electrodes, only certain di-electrics can be used.

Contrary to this prior art, it is the object of the invention to provide a device of the hereinbefore described type which is distinguished by a constant discharge and in which, furthermore, the disadvantages of other devices are, largely avoided. This objective is solved in a device of the hereinbefore described type according to the invention in that the primary and secondary windings of the high-frequency power transformer are linked closely to one another and are provided on a closed core with low magnetic dispersion. Preferably the high-frequency generator is an oscillator with a fixed frequency of not lower than 5 kHz and not higher than 70 kHz, while the inductances of the primary and secondary windings of the transformer form, together with the electrodes and counter electrodes, a resonant circuit to the energizing part consisting of the generator, the said inductances being adjustable.

In consequence it is not necessary to provide an oscillator having a continuously adjustable frequency for control of the end power output. Instead the invention makes possible an adaption of the loading in that the inductances of the primary winding and secondary winding are mechanically and/or electrically variable. This means, that the air gap of the transformer core is variable by mechanical means or by premagnetization using control means. Compared with conventional devices the device according to the invention is thus distinguished in that it does not utilize an open ferrite-core with matched secondary coils. As a result of using a closed ferrite-core magnetic dispersion is low or completely prevented. The self-induction of the coil has a variable value in the device according to the invention.

The possible adjustments are arranged in the device according to the invention in such a manner that the product of L and C in the resonant circuit has a constant value. Thus it is achieved that, with the fixed frequency emitted by the high-frequency generator, there is always a resistive loading C which is influenced by the treatment intensity, and by other variables. Thus L is accordingly variable in the device of the invention, in order to keep the product of L and C constant. This is achieved by the adjustability of the inductances of the high-frequency power transformer. In addition the invention also proposes the provision of a compensating member for the adjustment of the capacitances in the electrode system. Such a compensating member can consist of a coil situated on a ferrite-core, in which the magnitude of the inductance is adjustable mechanically or electrically. The compensating member is positioned between the high-frequency power transformer and the electrode, where the sparking area for the surface treatment is formed.

The surface treatment of synthetic resins, paper, metal or textile materials is carried out by means of a spark discharge, which occurs between an electrode and a counter electrode over one or two air gaps. The device according to the invention can be equipped with various electrodes of conventional

design. For example, one or both electrodes may be stationary, one or both electrodes rotating, and always at least one electrode is provided with a suitable di-electric, the choice of which, however, is not predetermined by the device.

Further advantages and features of the invention will be understood from the claims and from the following description and drawings, explaining and illustrating as examples, preferred embodiments of the invention and in which are:

FIG. 1 — a circuit diagram of a device according to the invention, illustrated in a simplified manner,

FIG. 2 — an equivalent-circuit diagram illustrated in a simplified manner,

FIG. 3 — an equivalent-circuit diagram of a loading related to a generator as used in the device according to the invention,

FIG. 4 — a simplified illustration of the treatment part,

FIGS. 5, 6 and 7 — modified designs of the treatment parts corresponding to the illustration of FIG. 4,

FIG. 8 — a partial illustration to an enlarged scale of a device according to FIG. 4 and 7 respectively.

The device according to the invention, see FIG. 1, substantially comprises three parts **10**, **12** and **18**. Part **10** includes a high-frequency generator having a fixed operational frequency. Preferably the operational frequency should not be lower than 5 kHz and not higher than 70 kHz.

To the high-frequency generator there is connected a high-frequency power transformer which consists of a primary coil **14** and a secondary coil **16**. According to the invention that type of a high-frequency power transformer is used in which the primary and the secondary windings **14** and **16** respectively are closely linked and are arranged on a closed ferrite-core with low magnetic dispersion. In FIG. 1 the ferrite-core is indicated by the dashed line **17** between parts **14** and **16**. In FIG. 2 the mutual inductance **15** is illustrated as an equivalent-circuit diagram of the high-frequency power transformer to the primary and secondary coil **14** or **16**. In accordance therewith there is indicated on the primary coil the total inductance, L*p*-M and on the secondary coil **16** the total inductance L*s*-M. The L*p* and L*s* are variable. The adjustment of the inductances of coils **14** and **16** is such that the inductances of both coils can be varied in a predetermined relationship.

The actual loading part **18** includes the ohmic resistance **20** of the sparking area, and also the capacitance **22** of the foil strip or web and the capacitance **24** of a roller coating. In the simplified equivalent-circuit diagram of FIG. 2 there is illustrated the ohmic total resistance **20'** and the total capacitance **26'** of the loading part **18**. Loading part **18**, see FIG. 4 has, e.g., a metal roller **30**, which is provided with a roller coating **32** of a dielectric material. The roller **30** is earthed, see FIGS. **1** and **4**. Over the roller **30** extends the foil or web strip F, which is subjected to the electrical sparking area emanating from the metal electrode **36**.

In FIG. 3 parts **12** and **18** of the device shown in FIG. **1** and **2** are combined into an equivalent-circuit diagram as the loading part of the high-frequency generator **11**. Said loading part includes the resistance **20''** formed by the sparking resistance, and furthermore by the resulting total capacitance **26''** and the resulting total inductance **28''**. According to the invention provisions are made to ensure that the result is substantially a pure resistive loading for the high-frequency generator **11**. For this purpose it is proposed that the product of inductance and capacitance should give a constant value. Since the capacitance is influenced by the treatment intensity and by other variables it is accordingly possible to maintain constant the product of LC by adjustment of the inductance of the high-frequency power transformer. Setting of the power transformer makes possible also the use of the device according to the invention with different electrode arrangements. According to FIG. **5** the foil or web strip F is situated between two electrode rollers **40**, **42**, the clearance of the rollers **40**, **42** being such that an air gap with respect to the corresponding roller **40** is maintained on the upper side of the foil or web strip F as well as the clearance on the lower sides.

FIG. 6 illustrates an embodiment in which the foil or web strip F is situated below a roller electrode **50**. Thus the foil or web strip F is drawn over a roller-shaped counterelectrode **52**. In order to improve adaptation of the electrodes it is possible to provide coil **54** as a compensating member between the high-frequency power transformer and the electrode **50**. The adjustment coil **54** is provided with a ferrite-core. The magnitude of the inductance of the adjustment coil **54** can be altered either machanically or electrically. Such an arrangement is illustrated in FIG. **7**, for a stationary electrode **60** and a roller-shaped counter electrode **62**, the adaptation being improved by means of the compensating member which is designed as an adjustment coil **54'**.

It is also possible to design the compensating member **54**, as with parts **12** or **18** of the device according to the invention, as a closed unit which, if required, is connected to the remaining parts of the device.

FIG. **8** illustrates a section of FIG. **4** to an enlarged scale. The reference numerals are the same as in FIG. **4** and have the same meaning. FIG. **8** illustrates that the active capacitance of the treatment arrangement C is dependant on the treatment intensity.

The device according to the invention differs from conventional devices in that an even spark discharge from the electrodes is directed onto the material which is to be pre-treated. The spark discharge is effected constantly without interruption between the separate high-frequency periods. With treatment with a device according to the invention a large amount of ozone is liberated, which has proved advantageous for preparation for adhesion of e.g. color or adhesive. Devices of the type as proposed by the invention can be used for very many purposes because it is possible to select the electrode which is most suitable for each particular type of treatment.

What we claim is:

1. In an electrical circuit, an apparatus for providing a controllable spark discharge to an electrode load in the treatment of a material web, in which the characteristics of the electrical load circuit may vary with changes in the electrode arrangement and the physical characteristics of the material web, comprising:

a source of electrical power capable of supplying electrical energy at a single frequency;

a transformer coupling said power source to the electrode load, said transformer having close coupled primary and secondary windings on a substantially closed ferrite-core;

means for varying the inductance of said transformer to maintain the inductance and capacity of the circuit including said transformer and the electrical load in a predetermined relationship; and

a spark discharge load circuit comprising a first metal electrode connected to a first terminal of said coupling transformer secondary winding, a second metal electrode connected to a second terminal of said coupling transformer secondary winding, and means for supporting said material web between said first and second electrodes to permit the spark discharge current to flow from said first electrode through said material web to said second electrode, said spark dicharge load circuit having substantial capacity and resistance.

2. An electrical apparatus according to claim **1** wherein said means for varying the inductance of said transformer includes means for adjusting the air gap of the ferrite-core.

3. An electrical apparatus according to claim **1** wherein said means for varying the inductance of said transformer includes premagnetization of the ferrite-core.

4. In an electrical circuit, an apparatus for providing a controllable spark discharge to an electrode load in the treatment of a material web, in which the characteristics of the electrical load circuit may vary with changes in the electrode load arrangement and physical characteristics of the material web, comprising

a source of electrical power capable of supplying electrical energy at a single frequency;

a transformer connected to said power source, said transformer having close coupled primary and secondary windings on a substantially closed ferrite-core;

a spark discharge load circuit comprising a first metal electrode connected to a first terminal of said coupling transformer secondary winding, a second metal electrode connected to a second terminal of said coupling transformer secondary winding and means for supporting said material web between said first and second electrodes to permit the spark discharge current to flow from said first electrode through said material web to said second electrode, said spark discharge load circuit having substantial capacity and resistance; and

an adjustment coil connected in series with said transformer in said spark discharge load circuit, said adjustment coil having a ferrite-core with adjustable magnetic properties for varying the inductance.

* * * * *