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Sato et al.

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[54] **FLYBACK TRANSFORMER DEVICE**

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[52] **U.S. Cl.** **336/94**

[51] **Int. Cl.** **H01f 27/02**

[58] **Field of Search** .... 336/90, 92, 94; 321/8 C, 2 HF; 317/14; 315/27

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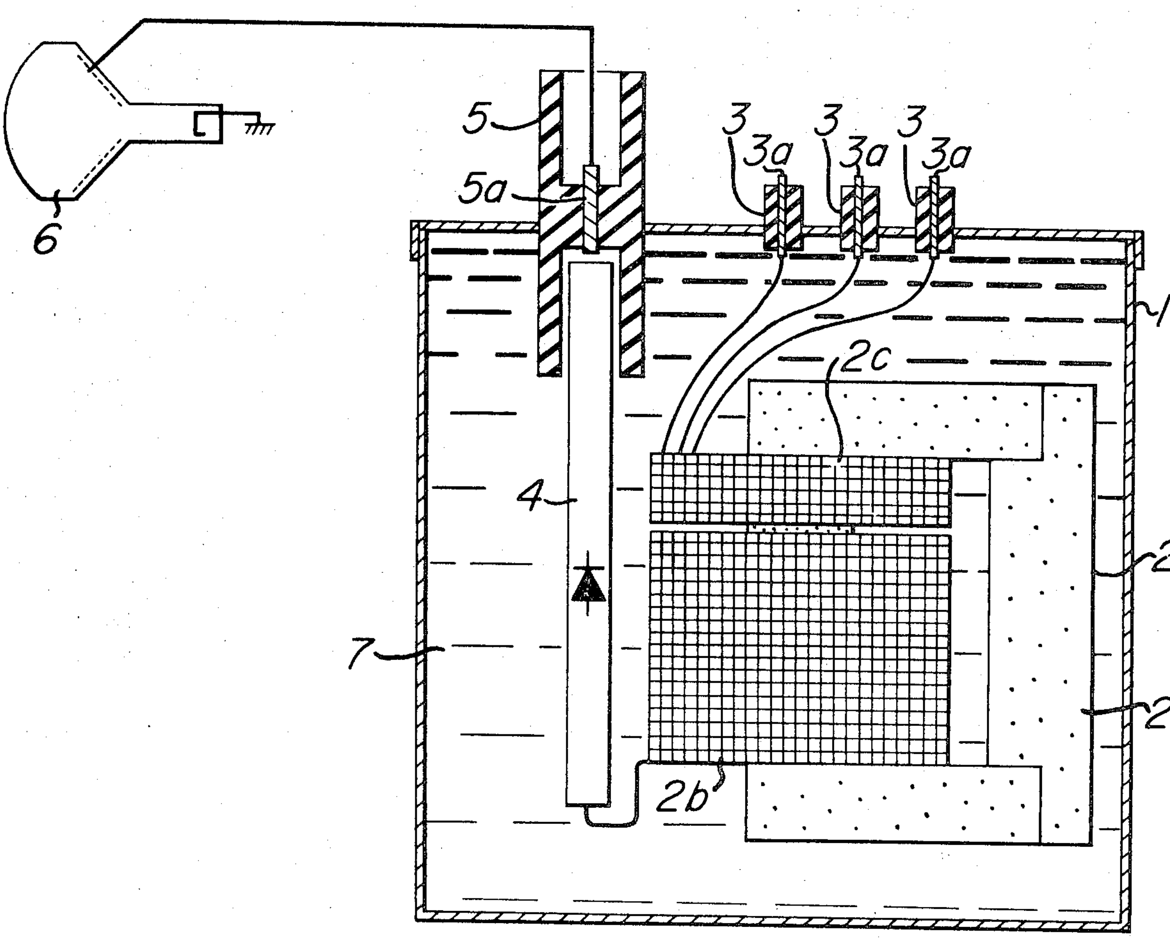
[57] **ABSTRACT**

A flyback transformer device wherein a flyback transformer and diode are accommodated in a hermetically sealed metal container which is filled with insulating oil whose amount of charge resulting from corona discharge is less than a predetermined value.

3 Claims, 5 Drawing Figures



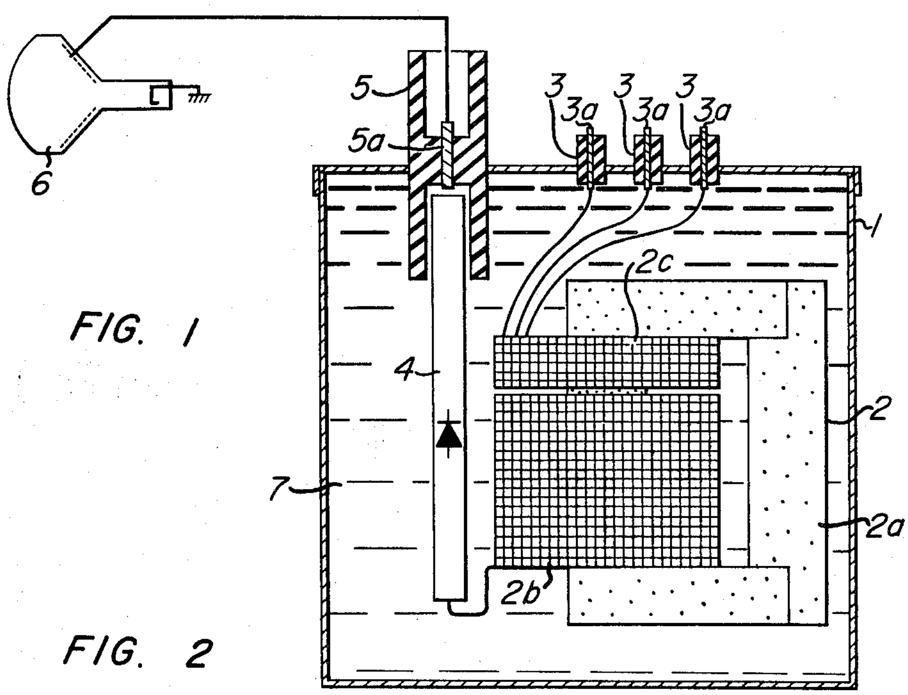

5
5a
3
3a
3
3a
3
3a
6
1
2c
4
2
7
2a
2b

FIG. 1

FIG. 2

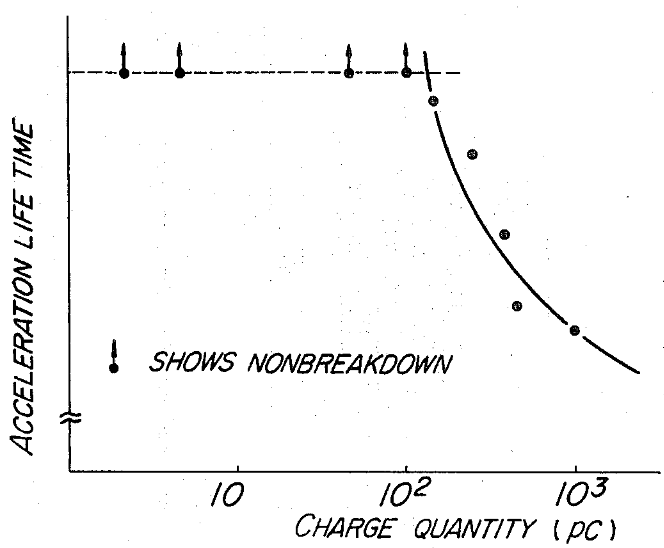

ACCELERATION LIFE TIME
SHOWS NONBREAKDOWN
10
10²
10³
CHARGE QUANTITY (pc)

FIG. 3

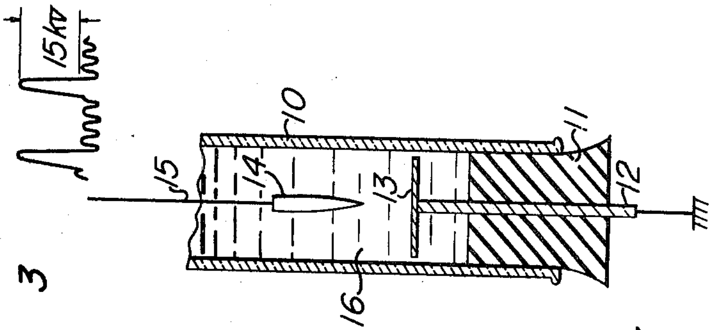

15kv
10
11
12
13
14
15
16

FIG. 4

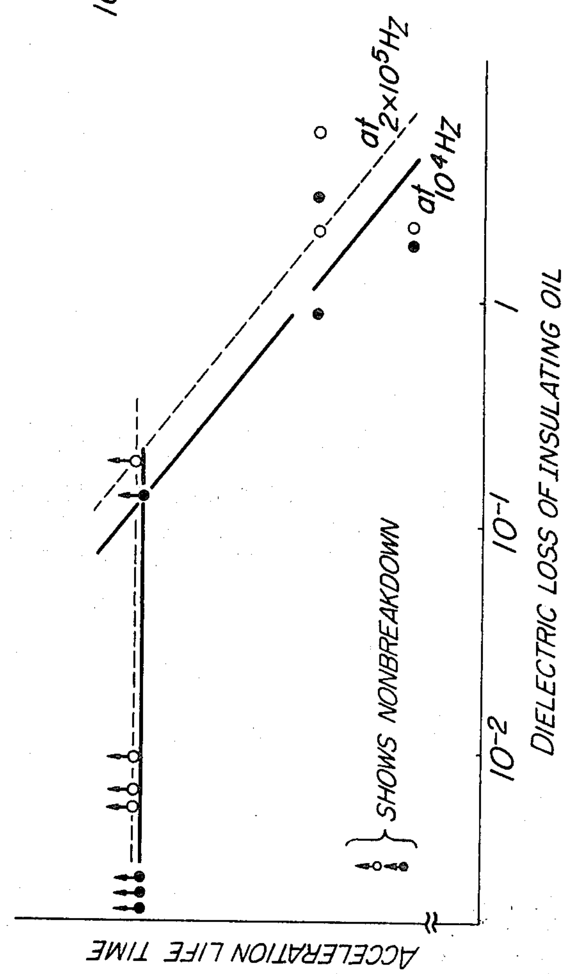
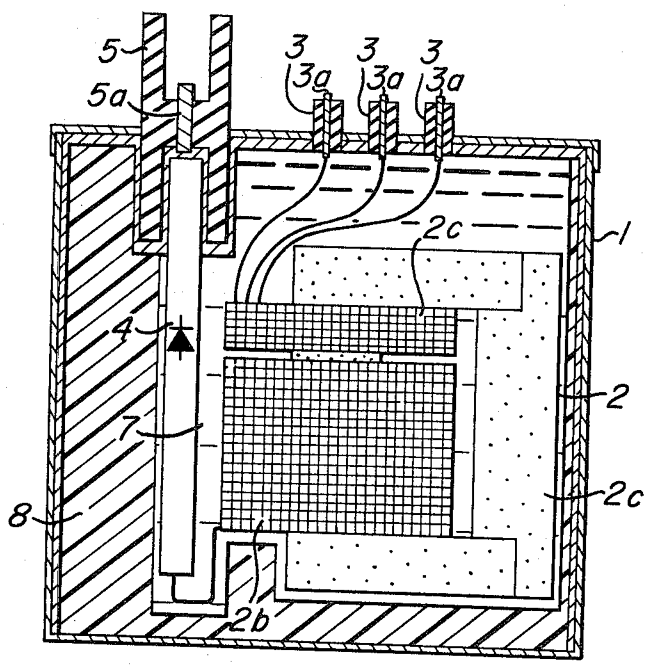

at 2×10^5 Hz
at 10^4 Hz
SHOWS NONBREAKDOWN
10^-2
10^-1
1
DIELECTRIC LOSS OF INSULATING OIL
ACCELERATION LIFE TIME

FIG. 5



FLYBACK TRANSFORMER DEVICE

This invention relates to a flyback transformer device for use with television receivers, and particularly to the construction of and materials constituting such a flyback transformer device.

The objects, features and advantages of the present invention will become apparent from the accompanying drawings, in which:

FIG. 1 is a sectional view showing the flyback transformer according to an embodiment of the present invention;

FIG. 2 is a graph showing the relationship between the amount of charge resulting from corona discharge in insulating oil and the acceleration life time;

FIG. 3 is a sectional view of an apparatus for measuring the quantity of charge resulting from corona discharge in the insulating oil;

FIG. 4 is a graph showing the relations of the accelerating life time to the dielectric loss of the insulating oil; and

FIG. 5 is a sectional view showing the flyback transformer according to a second embodiment of this invention.

Referring first to FIG. 1 of the drawings, there is shown the basic construction of the flyback transformer device embodying the present invention, wherein numeral **1** represents a hermetically sealed metallic container in which is accommodated a transformer **2** which is adapted to produce a high-frequency high voltage upon being impressed with an input through a low-voltage terminal **3** from outside. The high-frequency high voltage thus produced is rectified by a high-voltage diode **4** and then taken out through a high-voltage terminal **5** to be connected with a picture tube **6.** The space in the hermetically sealed container is entirely vacuum-impregnated with insulating oil as shown at **7** so that no gas portion is present within the container.

The flyback transformer **2** comprises a core **2***a*, primary coil (primary winding) **2***c*, and high voltage coil (secondary winding) **2***b*, the low-voltage and high-voltage terminals **3** and **5** including conductors **3***a* and **5***a* for connecting the inside of the container to the outside respectively.

With the flyback transformer device having the aforementioned construction, its dielectric strength is greatly increased because of the presence of the insulating oil so that the distance for insulation can be reduced, which makes an effective contribution to miniaturization of the flyback transformer device. With regard to the stability, safety and so forth for a long life span, however, serious problems arise which cannot be solved only by increasing the dielectric strength. The more important of such problems will be explained below.

1. With the oil-insulating system, the distances for insulation between the various parts within the flyback transformer device can be reduced so that the device per se can be effectively miniaturized; however, at the conductor surfaces to which the high voltage flyback pulse is imparted, it is more likely that corona discharge occurs in the oil, and moreover the quantity of charge resulting from the corona discharge in the oil is very large as compared with the case of the conventional flyback transformer device designed such that the insulation space between the transformer and the

metallic shield casing is large enough. With a flyback transformer device of the oil insulating system, it is necessary to thoroughly inhibit the occurrence of corona discharge in the oil since the speed of oil deterioration increases with an increase in the quantity of charge resulting from such discharge, whereas with a conventional device of air insulating system, even if a certain amount of corona discharge occurs, air diffusion prevents such discharge from leading to the destruction of the entire passage, and therefore such a problem has heretofore been overlooked. In the case of a flyback transformer device of the oil insulation system, therefore, it is essential that provision be made for means for achieving miniaturization of the device by restraining deterioration of the insulating material due to corona discharge.

2. Due to the fact that insulating oil is contained, if the device is externally heated or surrounded by flame, there is a possibility that the insulating oil is thermally expanded or evaporated so that the oil, either as it is or gassified, leaks and the thus leaking oil or gas is burnt.

3. Since the insulating oil is filled also between the coils constituting the flyback transformer and the container, stray capacitacne occurring therebetween is in proportion to the specific inductive capacity of the insulating oil. Moreover, as compared with the case of a conventional flyback transformer device, the stray capacitance is increased because of the reduced spacing between the coil mentioned above and the container. Obviously this will have an adverse effect on the performance of the flyback transformer device in that the width of the flyback pulse is increased, the ringing pulse becomes close to the basic wave, and so on. For example, there is a tendency for the picture to be subject to greater distortion and/or disturbance, an increased amount of heat to be produced in the flyback transformer, and so on.

Concrete methods of solving the aforementioned problems will be described in detail below.

1. Restraint of corona discharge in the oil

In a flyback transformer which is miniaturized by adopting the oil insulating system, an extremely intense electric field occurs at the surfaces of the high voltage coil wires to which the high voltage flyback pulse is imparted, lead-out wires thereof and lead-out wires of the high voltage diode since each of these wires has a small diameter, and therefore there is likelihood that corona discharge occurs there. In order to avoid this, the curvature of those portions to which an intense electric field is imparted may be increased, for example, by using wires of greater diameters or by covering the wires with spherical conductors of a greater curvature, so that the electric field may be weakened. From the standpoint of manufacture of design, however, difficulty is encountered in an attempt to apply such means to all the portions. (If a coil wire having a greater diameter is used for example, the size of the flyback transformer is increased so that the entire flyback transformer device becomes bulky.) Hence, it is difficult to solve the problems described above only through the use of such means.

A reasonable and economical construction can be achieved by using insulating oil with a high corona discharge starting voltage and corona resistance in addition to taking the aforementioned countermeasures with respect to those portions where it is possible. However, the determination of corona discharge starting voltage the high voltage charging portion is imperfect since it depends upon the sensitivity of means for detecting corona discharge, its electrode construction condition thereof and so forth. Therefore, the quantity of charge resulting from corona discharge is measured with such an electrode construction and applied voltage that an easily measurable degree of corona discharge occurs, and it has been found that there is a very close co-relation between the charge quantity thus measured and the result of an accelerated life test performed with a flyback transformer device using the same kind of insulating oil as in the present invention. FIG. 2 is a graph showing the result, from which it will be seen that the life span changes sharply, with a corona discharge charge quantity of about 100 pico coulomb (pC) as the boundary, when a voltage of 15 KVp (flyback pulse) is applied. Referring now to FIG. 3, there is shown an electrode arrangement which is so designed that the liability of occurrence of a corona discharge in the insulating oil can be measured with ease, wherein numeral **10** represents an insulator tube of Pyrex glass about **30** mm in inner diameter with a closure **11** fitted therein through which extends a conductor **12** having a flat electrode **13** provided at the upper end thereof. A needle electrode **14** is provided in opposing relationship to the flat electrode **14** at a position spaced apart from the latter by 5 mm. The space in which these electrodes are disposed is filled with insulating oil to be tested. The conductor **12** is grounded, and the needle electrode **14** is connected with the high voltage flyback pulse of 15 KVp through a high voltage lead **15** and also with a device for measuring the quantity of charge stemming from corona discharge. The needle electrode is so worked that the point end thereof has a radius of curvature of 20 μm.

In this specific example, measurements were made of the quantity of charge stemming from corona discharge when flyback pulse of 15 KVp was imparted. As a result, it has been found that mineral oil, silicone liquid and alkylbenzene gave the best results. This can be observed in any flyback transformer device. The reason is that the electric field acting on the insulating oil inside the flyback transformer device is an electric field of a high frequency called a flyback pulse except for a portion thereof and therefore the behavior of the oil is quite different from that of insulating oil commonly used in commercial frequency power apparatus.

It has been found that if noninflammable insulating oil (diphenyl chloride group) which is now extensively used in power transformers or the like, for example, is employed in the flyback transformer according to this invention, deterioration is caused in a shorter time than in the case where silicone liquid is used as insulating oil. The fact that such a result is obtained despite the fact that the short-time destruction voltage (A.C.) stemming from the sphere gap of such noninflammable insulating oil is 20 – 30 percent higher than in the case of silicone liquid, for example, shows the uniqueness of the characteristics required of the flyback transformer device according to this invention. In the case where an electric field of a high frequency such as a flyback pulse is applied, insulating oil under such an electric field is caused to start corona discharge at a lower electric field than in the case where a commercial frequency electric field is applied. This is due to the fact that the speed of deterioration of the insulating oil is accelerated more than the frequency ratio due to the abnormality of the waveform and dielectric heating. In general, the frequency of a the basic wave of flyback pulse is about three times as high as the repetition rate of the flyback pulse; in the case where the repetition rate is 15.75 KHz, the basic wave frequency is approximately 35 to 45 KHz. Since the ringing pulse superimposed upon the flyback pulse has a frequency three to five times as high as that of the basic wave, the frequency of the ringing pulse in the aforementioned case becomes 100 to 200 KHz.

Furthermore, dielectric loss (tan.δ) occurs in an infinitesimal portion of the insulating oil to which a high frequency electric field is applied, and as it increases, the dielectric loss density (W/cm^3) in that portion is increased so that however small the aforementioned portion may be, this portion of the insulating oil is heated to a high temperature so as to be subject to thermal decomposition, evaporation, emission of dissolved gas or the like. Thus, an infinitesimal void is formed in the oil, which becomes a cause for corona discharge. FIG. 4 shows the relationship between the dielectric loss of various types of insulating oil at 25°C and the result of acceleration life tests performed in a manner similar to that described with reference to FIG. **2.** From this, it will be noted that it is desirable that the dielectric loss of the insulating oil to be used be less than 1×10^{-1} in a frequency range of $10^4 - 2 \times 10^5$ Hz.

2. Noninflammability

It is a well known and extensively adopted technique to use noninflammable oil of the diphenol chloride group as insulating oil with the view to improving apparatus with respect to safety; however, it has been seen from the foregoing that in the case of the flyback transformer according to this invention, it is inappropriate to employ such noninflammable insulating oil. In the flyback transformer device according to this invention, there is no possibility that a short-circuit or a discharge accident tending to lead to fuming or combustion occurs which sometimes happens in the conventional dry type flyback transformer device impregnated with wax or the like. However, using mineral oil, alkylbenzene or the like as insulating oil cannot be said to be the best means, when consideration is given to such cases that the flyback transformer is externally exposed to flame or excessive heat due to an accident or fire taking place at the position where a television receiver incorporating the flyback transformer device is located.

Silicone liquid cannot be said to be non-inflammable itself; however, it has been found that in the case where it is used as insulating oil for the flyback transformer device according to this invention, silicone liquid is superior to certain kinds of non-inflammable insulating oil in that it is very stable, without fuming, with respect to external flame or the like. Thus, by using silicone liquid as insulating oil, the noninflammability of the flyback transformer device according to the present invention is greatly improved.

3. Specific inductive capacity

From the standpoint of designing the flyback transformer device, it is obviously desirable that the specific inductive capacity (measured at the frequency of the flyback pulse basic wave or ringing pulse) of the insulating oil adapted for use in the present invention be close to unity. In the present invention, however, it is of paramount importance to select insulating oil from the standpoint of corona discharge. This implies that the flyback transformer device should be so designed as to represent improved characteristics whatever value the specific inductive capacity of the insulating oil in use may have. If the specific inductive capacity of the insulating oil to be used has a value up to **4**, it is possible to construct a flyback transformer device having satisfactory characteristics by correspondingly changing the numbers of turns of the coils, outer diameters of the windings and positional relationship between the primary coil (primary winding) and the high voltage coil (secondary winding), though the situation differs to some extent depending upon the spacing between the hermetically sealed container and the coil surfaces. Moreover, in the cases where use is made of insulating oil having a specific inductive capacity greater than the aforementioned value, it has been found that readily acceptable characteristics can be achieved by increasing the size of the sealed container, the coating thickness of the coil wire and so forth and by constructing the flyback transformer device as shown in FIG. **5**. Description will now be made in connection with FIG. **5**, wherein numerals **1** to **7** indicate elements corresponding to those shown in FIG. **1** respectively, and **8** denotes a spacer molded of a material having a low specific inductive capacity such for example as polypropylene or the like. The spacer **8** is interposed between the sealed container **1** and the flyback transformer **2**, serving to reduce stray capacitance which occurs therebetween and decrease the required quantity of the insulating oil to be used so as to reduce the extent of expansion and contraction of the oil which depends upon the temperature thereof.

With such an arrangement, most of those kinds of insulating oil which have extensively been used at the present time can be employed in view of the operational characteristics of the flyback transformer device.

The advantages of the present invention have already been described above, and therefore, in order to avoid repetition, only the major ones will be mentioned below.

i. The present flyback transformer device can be greatly miniaturized so that the bulk thereof can be made as small as about one-fifth of that of the conventional device.

ii. High safety can be achieved.

iii. High reliability on electric insulation can be achieved, and a long life span can be secured.

iv. Where silicone liquid is used as insulating oil, by using the aforementioned spacer in combination therewith, it is possible to reduce the required quantity of the expensive silicone liquid. Furthermore, because of the fact that the thermal expansion coefficient of silicone liquid is about 10 percent higher than those of other kinds of insulating oil, it is also possible to decrease the amount of respiration which is required of the sealed metallic container to cope with temperature variations occurring in the flyback transformer device by reducing the quantity of the silicone liquid to be used.

What is claimed is:

1. A flyback transformer device comprising a hermetically sealed metallic container; a flyback transformer and a high voltage diode accommodated within said hermetically sealed metallic container, electric power being provided to said flyback transformer from outside said container to provide a high D.C. voltage output by rectifying the high voltage pulses appearing in said flyback transformer; and insulating oil filling the entire space within said hermetically sealed metallic container including small gaps therein, said insulating oil being characterized by the quantity of charge stemming from a corona discharge occurring between a needle electrode and a flat electrode (the point end of said needle electrode has a radius of curvature of 20 μm, and the spacing between said two electrodes is 5 mm) immersed in said oil being 100 pico coulomb (pC) of less when a flyback pulse of 15 KVp is applied to said electrode.

2. A flyback transformer device according to claim **1**, wherein use is made of insulating oil of which the dielectric loss is less than 1×10^{-1} at 25°C in a frequency range of 10^4 to 2×10^5 Hz.

3. A flyback transformer device according to claim **1**, wherein said insulating oil, use is made of silicone liquid.

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