Title: SMD VARISTOR AND METHOD OF MANUFACTURING THE SAME

Abstract: Disclosed herein are an SMD varistor and a method of manufacturing the SMD varistor. The SMD varistor is constructed so that two ceramic bodies are integrally connected in parallel. Thus, voltage of the SMD varistor is equal to that of a conventional product using one ceramic body, but the surge absorbing capability of the SMD varistor dependent on the current is doubled. The present invention is capable of efficiently suppressing high-energy surges generated in a car, especially a load dump generated when a motor is started, thus efficiently coping with EMC required in cars.

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For two-letter codes and other abbreviations, refer to the “Guidance Notes on Codes and Abbreviations” appearing at the beginning of each regular issue of the PCT Gazette.
SMD VARIOR AND METHOD OF MANUFACTURING THE SAME

[Technical Field]

The present invention relates, in general, to an SMD varistor and, more particularly, to an SMD varistor capable of efficiently absorbing surge voltage and a method of manufacturing the SMD varistor.

[Background Art]

Recently, there has been a rapid development of the semiconductor industry and an acceleration of the integration rate of realizing miniaturization and high performance of a unit device. Thus, the operating voltage of electronic equipments or the like have a tendency of being gradually reduced. Conversely, when a surge voltage is applied, thermal energy high enough to burn electronic parts is generated, thus rapidly reducing the energy carrying capacity of a semiconductor. Therefore, the capability to cope with surges has been dramatically reduced.

Devices may be destroyed or degraded even when excessive voltage is supplied for a relatively short duration of several microseconds (μs) because equipments including semiconductor devices are susceptible to excessive voltage. , and thus, reducing the lifespan of equipments or deteriorating the functionality of the equipments. For these reasons, it is necessary to develop a varistor that can be
operated at micro-voltage.

A varistor is defined as a semiconductor device having a highly nonlinear volt-ampere characteristic. The electrical characteristics of the varistor are similar to the function of a Zener diode, which has constant voltage characteristics. However, the varistor is a composite ceramic device that has larger current and energy capacity.

The nonlinear characteristic of the varistor has very large electric resistances at low voltages. The resistance has a grain boundary phenomenon showing the nonlinear characteristic. That is, when voltage exceeds a predetermined threshold voltage depending on the microstructure and size of the device, the electric resistance is abruptly reduced.

The nonlinear resistance characteristic is controlled by a process that occurs at the grain boundary. The nonlinear resistance characteristic is similar to a breakdown, which is observed at a back-to-back Zener diode, but has larger energy absorbing capability.

Varistors have been used to stabilize voltage, quench sparks of contact points, or absorb surges in electronic circuits. Further, the varistors may be employed in an arrester for protecting an electrical system from lightning.

Meanwhile, "SMD" stands for "surface mountable device." A conventional device is mounted to a hole that is bored in a printed circuit board (PCB). However, the SMD is directly soldered to a pattern of a PCB, without the necessity of boring a
hole in the PCB. As an example of the SMD, an SMD element (referred to as a chip resistor), an SMD transistor (referred to as a chip transistor), an SMD varistor (referred to as a chip varistor), and etc. have been proposed.

As shown in FIG. 1, the SMD varistor is manufactured by the following process. That is, a ceramic body 101 is prepared. An electrode 102 is applied to a surface of the ceramic body 101, while an electrode 104 is applied to an opposite surface of the ceramic body 101. Lead plates 103 and 105 are bent and soldered to the electrodes 102 and 104, respectively, so as to connect the electrodes 102 and 104 to a circuit (e.g. printed circuit board). Afterwards, a coating process is carried out using an insulating material, such as epoxy 107.

【Disclosure】

【Technical Problem】

Recently, due to the miniaturization of electronic equipment and integration of an electronic circuit, a varistor suitable for a wide range of use has been developed. For example, a varistor used for the interior of a car or a computer must absorb a surge voltage of 20V or less.

However, when the conventional SMD varistor shown in FIG. 1 is applied to a car, the SMD varistor is problematic in that it has one ceramic body, so that it is difficult to absorb a surge having high energy generated by the car, especially a load
dump.

Thus, due to the recent trend toward the electronization of cars, it is difficult to cope with electromagnetic compatibility (EMC), which is required in cars.

Accordingly, the present invention has been proposed to solve the problems.

An object of the present invention is to provide an SMD varistor having the capability to absorb a double amount of surge and a method of manufacturing the varistor.

【Technical Solution】

In order to accomplish the above object, the present invention provides an SMD varistor, including a first ceramic body having a plate shape, with a first electrode and a second electrode provided respectively on opposite surfaces of the first ceramic body, a second ceramic body having a plate shape, with a third electrode and a fourth electrode provided on opposite surfaces of the second ceramic body, the second ceramic body being arranged such that the third electrode faces the second electrode, a first lead plate including first and second connection parts provided on a first end of the first lead plate and connected to the first electrode and the fourth electrode, respectively and a second end to be connected to an exterior, a second lead plate including a first end interposed between the second and third electrodes and connected to the second and third electrodes and a second end to be connected to the exterior, and a molding part surrounding the first and second connection parts of the first lead plate,
the first end of the second lead plate, and the first and second ceramic bodies.

Further, the first lead plate is manufactured by cutting an end of a long conductive plate longitudinally to a predetermined length so as to be divided into the first and second connection parts, bending the first connection part in a predetermined direction, and bending the second connection part in a direction opposite to that of the first connection part.

Furthermore, the first lead plate is manufactured using a mold constructed to form the first and second connection parts that are bent in opposite directions such that the first connection part of the first lead plate is bent in a predetermined direction, and the second connection part of the first lead plate is bent in a direction opposite to that of the first connection part.

In order to accomplish the above object, the present invention provides a method of manufacturing an SMD varistor, including the steps of arranging a first ceramic body having on opposite surfaces thereof a first electrode and a second electrode and a second ceramic body having, on opposite surfaces thereof, a third electrode and a fourth electrode such that the first and second ceramic bodies are in parallel with each other, connecting first and second connection parts of a first lead plate to the first and fourth electrodes, respectively, inserting a first end of a second lead plate between the second and third electrodes, thus connecting the first end of the second lead plate to the second and third electrodes, and forming a molding part that
surrounds the first and second connection parts of the first lead plate, the first end of 
the second lead plate, and the first and second ceramic bodies.

Further, according to the present invention, the first connection part of the first 
lead plate is bent in a predetermined direction, and the second connection part of the 
first lead plate is bent in a direction opposite to that of the first connection part by 
longitudinally cutting an end of a long conductive plate to a predetermined length so as 
to divide the end into two parts which are the first and second connection parts of the 
first lead plate, and by bending the first connection part in a predetermined direction, 
and by bending the second connection part in a direction opposite to that of the first 
connection part.

Furthermore, the first connection part of the first lead plate is bent in a 
predetermined direction, and the second connection part of the first lead plate is bent in 
a direction opposite to that of the first connection part by forming the first lead plate 
using a mold constructed to form the first and second connection parts, which are bent 
in opposite directions.

【Advantageous Effects】

According to the present invention, an SMD varistor is constructed so that two 
ceramic bodies are integrally connected in parallel. Thus, the voltage of the SMD 
varistor is equal to that of a conventional product using one ceramic body, but the
surge absorbing capability of the SMD varistor corresponding to the current is doubled. The present invention is capable of efficiently suppressing high-energy surges generated in a car, especially a load dump generated when a motor is started, thus efficiently coping with EMC required in cars.

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【Description of Drawings】

FIG. 1 is a view illustrating the construction of a conventional SMD varistor;

FIG. 2 is a perspective view of an SMD varistor, according to an embodiment of the present invention;

10 FIG. 3 is a side sectional view of the SMD varistor taken along line A-A of FIG. 1;

FIG. 4 is a top view of the SMD varistor of FIG. 1;

FIG. 5 is a table showing dimensions of parts constituting the SMD varistor of FIGS. 3 and 4;

15 FIGS. 6 through 11 are views showing the process of manufacturing the SMD varistor of FIG. 2;

FIG. 12 is a perspective view of an SMD varistor, according to another embodiment of the present invention; and

FIG. 13 is a perspective view showing a first lead plate and a second lead plate of the SMD varistor of FIG. 12.
*Description of reference characters of important parts*

1: SMD varistor
3, 4: bodies

5: first lead plate
5a: first connection part

5b: second connection part
7: second lead plate

8: molding part

【Mode for Invention】

The present invention will now be described in detail with reference to the accompanying drawings.

FIG. 2 is a perspective view of an SMD varistor according to an embodiment of the present invention, FIG. 3 is a side sectional view of the SMD varistor taken along line A-A of FIG. 1, and FIG. 4 is a top view of the SMD varistor of FIG. 1.

As shown in FIGS. 2 to 4, the SMD varistor 1 includes upper and lower bodies 3 and 4, first and second electrodes 13 and 14, third and fourth electrodes 15 and 16, first and second lead plates 5 and 7, and a molding part 8. The upper and lower bodies 3 and 4 are made of a ceramic material, and are provided at upper and lower positions of the SMD varistor 1, respectively, such that the upper and lower bodies 3 and 4 are spaced apart from each other by a predetermined interval. The first and second electrodes 13 and 14 are provided on opposite surfaces of the upper body 3,
that is, upper and lower surfaces of the upper body 3, respectively. The third and fourth electrodes 15 and 16 are provided on opposite surfaces of the lower body 4, that is, upper and lower surfaces of the lower body 4. The first and second lead plates 5 and 7 are disposed on both ends of a pair of bodies 3 and 4. The molding part 8 is formed to surround the upper and lower bodies 3 and 4, part of the first lead plate 5, and part of the second lead plate 7.

The first lead plate 5 has, on a first end thereof, a first connection part 5a and a second connection part 5b. The first connection part 5a and the second connection part 5b are connected to the first electrode 13 of the upper body 3 and the fourth electrode 16 of the lower body 4, respectively. A second end 5c of the first lead plate 5 is attached to a lower surface of the molding part 8.

A first end of the second lead plate 7 is inserted between the second electrode 14 of the upper body 3 and the third electrode 15 of the lower body 4, and is simultaneously connected to both of the electrodes 14 and 15. Further, a second end of the second lead plate 7 is attached to the lower surface of the molding part 8.

FIG. 5 is a table showing dimensions of parts constituting the SMD varistor of FIGS. 3 and 4. The table of FIG. 5 shows adequate dimensions for the width (m) and the length (l) of the bodies 3 and 4, the width (m) and the length (k) of each electrode 13 -16, the length (a) of a part which is provided on the first connection part 5a of the first lead plate 5 in such a way as to be bent toward an upper surface of the upper body
3, the length (b) of a part which is provided on the second connection part 5b of the first lead plate 5 in such a way as to be bent toward the lower surface of the lower body 4, the length (c) of a part which is provided on the first end of the second lead plate 7 and is inserted into the molding part 8, and the length (d) of a part which is provided on the second end 5c of the first lead plate 5 in such a way as to be bent toward the lower surface of the molding part 8.

Further, the table of FIG. 5 shows adequate dimensions for the thickness (e) of the upper and lower bodies 3 and 4, the length (h) of a part which is provided on the second end of the second lead plate 7 in such a way as to be bent toward the lower surface of the molding part 8, the distance (g) between the lower surface of the lower body 4 and the lower surface of the molding part 8, the thickness (f) of the molding part 8, the width (i) of the first lead plate 5, and the width (j) of the first connection part 5a.

The dimensions of FIG. 5 are merely examples but may be changed to suit a manufacturing process. It is preferable to determine optimum dimensions by testing.

FIGS. 6 through 11 are views showing the process of manufacturing the SMD varistor according to the present invention.

At the first step, as shown in FIGS. 6 and 7, a long plate comprising a conductor made of a predetermined material (e.g., tin-plated Cu alloy) is prepared. One of the ends of the plate is cut longitudinally to be divided into the first connection
part 5a and the second connection part 5b. Next, the first connection part 5a is upwardly bent in two places to have a "Γ" shape. Meanwhile, the second connection part 5b is bent downwardly in two places to have an "L" shape, so the second connection part 5b is symmetrical with respect to the first connection part 5a. Therefore, the first lead plate 5 is finished.

Next, the second lead plate 7 is prepared. The second lead plate 7 has a shape of a long plate comprising a conductor made of a predetermined material (e.g., tin-plated Cu alloy).

At the second step, the upper and lower bodies 3 and 4, which have rectangular plate shapes and are made of a ceramic material, are prepared. The upper body 3 has, on opposite surfaces thereof, the electrodes 13 and 14, and the lower body 4 has, on opposite surfaces thereof, the electrodes 15 and 16. As shown in FIG. 8, the upper and lower bodies 3 and 4 are arranged to be spaced apart from each other by a predetermined distance in a vertical direction.

Meanwhile, the body of the varistor may be manufactured by the following process. That is, zinc oxide, bismuth, cobalt, manganese, nickel, etc. are mixed in predetermined proportions. The mixture produced as an oxide is sprayed and dried. Afterwards, a product having a rectangular parallelepiped shape is formed using a rectangular mold. Next, the product is sintered in an electric furnace according to a specific rising temperature curve. Thereafter, electrodes are printed on opposite
surfaces of the product to obtain the body.

The first end of the second lead plate 7 is inserted between the upper and lower bodies 3 and 4 and is connected to the second and third electrodes 14 and 15 through soldering.

Next, at the third step, as shown in FIG. 9, the first connection part 5a of the first lead plate 5 is soldered to the first electrode 13 of the upper body 3, and the second connection part 5b of the first lead plate 5 is soldered to the fourth electrode 16 of the lower body 4.

During the soldering operation, the first and second connection parts 5a and 5b of the first lead plate 5 are spaced apart from the left sides of the upper and lower bodies 3 and 4 by a predetermined distance (e.g., about 0.5mm) so that the first and second connection parts 5a and 5b are not in contact with the left sides of the upper and lower bodies 3 and 4. In this case, it is preferable that the spacing distance be short, because the consumption of epoxy molding compound (EMC) required for a molding process that forms the molding part 8 is reduced.

In order to solder the first and second lead plates 5 and 7 to the electrodes 13 - 16 of the bodies 3 and 4, various methods may be used. For example, overflow soldering is possible. The overflow soldering is carried out as follows. Solder paste is applied to the first and second lead plates 5 and 7 and the electrodes 13 - 16 of the bodies 3 and 4 through screen printing so as to connect the lead plates 5 and 7 to the
corresponding electrodes 13 - 16 of the bodies 3 and 4, prior to passing through a drier
so as to thermally fix the above-mentioned parts.

As another example, dipping soldering may be used. That is, the first and
second lead plates 5 and 7 are coupled to the electrodes 13 - 16 of the upper and lower
bodies 3 and 4. Next, soldering parts are covered with a solvent and preliminarily
heated, prior to being dipped in a solder bath.

As a further example, overflow soldering and general soldering may be used
together. That is, the second electrode 14 of the upper body 3 is located above the
second lead plate 7, and the fourth electrode 16 of the lower body 4 is located above
the second connection part 5b of the first lead plate 5. Thus, the second electrode 14
of the upper body 3 is connected to the second lead plate 7 and the fourth electrode 16
of the lower body 4 is connected to the second connection part 5b of the first lead plate
5 through the overflow soldering, thus preventing solder paste from flowing down.
Meanwhile, since solder paste present between the first connection part 5a of the first
lead plate 5 and the first electrode 13 of the upper body 3 located under the first
connection part 5a and solder paste present between the second lead plate 7 and the
third electrode 15 of the lower body 4 located under the second lead plate 7 do not
flow down, the parts may be connected to each other through general soldering.

At the fourth step, as shown in FIG. 10, a molding process is carried out such
that, part of the first lead plate 5, part of the second lead plate 7, the upper body 3, and
the lower body 4 are surrounded with epoxy. In a detailed description, the epoxy molding compound is cut by a predetermined amount. The cut epoxy molding compound is mounted to the mold along with the bodies 3 and 4 and the lead plates 5 and 7 that are soldered to each other. By performing injection molding using an injection molding machine under predetermined temperature and pressure, the molding part 8 is formed.

In this case, the temperature and pressure are varied depending on various conditions including materials of the epoxy molding compound. However, it is preferable that injection molding be carried out at a temperature of about 175° C and a pressure of 770psi (pounds per square inch).

At the fifth step, as shown in FIG. 11, the second end 5c of the first lead plate 5, provided outside the molding part 8, is bent in two places such that the second end 5c is in surface contact with and attached to the left surface and the lower surface of the molding part 8. Further, the second end of the second lead plate 7, provided outside the molding part 8, is bent in two places such that the second end is in surface contact with and attached to the right surface and the lower surface of the molding part 8. Through such a process, the SMD varistor of the present invention is realized.

FIG. 12 is a perspective view of an SMD varistor, according to another embodiment of the present invention. As shown in the drawing, the SMD varistor of FIG. 12 is equal to the SMD varistor of FIGS. 2 through 11, except for the method of
manufacturing first and second lead plates 25 and 27.

In a detailed description, according to the embodiment of FIGS. 2 through 11, by cutting and bending the long conductive plate, the connection parts 5a and 5b and the second end 5c of the first lead plate 5 are prepared. Next, the molding process is carried out. Subsequently, the second end 5c of the first lead plate 5 and the second end of the second lead plate 7 are bent to be attached to the molding part 8.

However, according to another embodiment of the present invention, as shown in FIG. 13, the first lead plate 25 and the second lead plate 27 each having a complete shape are manufactured by using a mold. Thereafter, a first connection part 25a and a second connection part 25b of the first lead plate 25 are connected to the first electrode 13 of the upper body 3 and the fourth electrode 16 of the lower body 4, respectively, by soldering. A first end 27a of the second lead plate 27 is inserted between the upper body 3 and the lower body 4 to be soldered and connected to the second electrode 14 and the third electrode 15.

Meanwhile, the first lead plate 25 and the second lead plate 27 may be separately manufactured in respective molds. According to another example, after the first and second lead plates 25 and 27 are integrally formed in a single mold, the junction of the first and second lead plates 25 and 27 may be cut so that the first and second lead plates 25 and 27 are separated from each other.

Another embodiment of the present invention is capable of omitting the
cutting and bending operation for making the first connection part 25a and the second
connection part 25b of the first lead plate 25, the operation of bending the second end
25c of the first lead plate 25, and the operation of bending the second end 27b of the
second lead plate 27. Thus, the manufacturing process is simplified.

As described above, the present invention provides an SMD varistor, which is
constructed so that two varistor bodies are integrally connected in parallel with each
other, thus doubling the surge absorbing capability dependent on the current, while
having the same voltage as a conventional varistor using one varistor body.

Therefore, the varistor of the present invention is capable of efficiently
absorbing high energy surges generated in a car, especially a load dump generated
when a motor is started, thus efficiently coping with EMC required in cars.

Although the preferred embodiments of the present invention have been
disclosed for illustrative purposes, those skilled in the art will appreciate that various
modifications, additions, and substitutions are possible, without departing from the
scope and spirit of the invention as disclosed in the accompanying claims.
[CLAIMS]

[Claim 1]

An SMD varistor, comprising:

a first ceramic body having a plate shape, with a first electrode and a second electrode provided respectively on opposite surfaces of the first ceramic body;

a second ceramic body having a plate shape, with a third electrode and a fourth electrode provided on opposite surfaces of the second ceramic body, the second ceramic body being arranged such that the third electrode faces the second electrode;

a first lead plate, comprising:

first and second connection parts provided on a first end of the first lead plate, and connected to the first electrode and the fourth electrode, respectively; and

a second end to be connected to an exterior;

a second lead plate, comprising:

a first end interposed between the second and third electrodes and connected to the second and third electrodes; and

a second end to be connected to the exterior; and

a molding part surrounding the first and second connection parts of the first lead plate, the first end of the second lead plate, and the first and second ceramic bodies.
【Claim 2】

The SMD varistor according to claim 1, wherein the first lead plate is manufactured by cutting an end of a long conductive plate longitudinally to a predetermined length so as to be divided into the first and second connection parts, bending the first connection part in a predetermined direction, and bending the second connection part in a direction opposite to that of the first connection part.

【Claim 3】

The SMD varistor according to claim 1, wherein the first lead plate is manufactured using a mold constructed to form the first and second connection parts that are bent in opposite directions such that the first connection part of the first lead plate is bent in a predetermined direction, and the second connection part of the first lead plate is bent in a direction opposite to that of the first connection part.

【Claim 4】

The SMD varistor according to claim 1, wherein the second end of the first lead plate and the second end of the second lead plate are bent to be in contact with an outer surface of the molding part.

【Claim 5】
The SMD varistor according to claim 4, wherein the second end of the first lead plate and the second end of the second lead plate have bent shapes through a bending operation.

【Claim 6】
The SMD varistor according to claim 4, wherein the second end of the first lead plate and the second end of the second lead plate are manufactured using a mold constructed to form bent shapes.

【Claim 7】
The SMD varistor according to claim 1, wherein the first and second connection parts of the first lead plate are spaced apart from side surfaces of the first and second ceramic bodies by a predetermined distance, so that the first and second connection parts do not contact with the side surfaces of the first and second ceramic bodies.

【Claim 8】
A method of manufacturing an SMD varistor, comprising the steps of:
arranging a first ceramic body having, on opposite surfaces thereof, a first electrode and a second electrode and a second ceramic body having, on opposite
surfaces thereof, a third electrode and a fourth electrode such that the first and second ceramic bodies are in parallel with each other;

connecting first and second connection parts of a first lead plate to the first and fourth electrodes, respectively;

inserting a first end of a second lead plate between the second and third electrodes, thus connecting the first end of the second lead plate to the second and third electrodes; and

forming a molding part that surrounds the first and second connection parts of the first lead plate, the first end of the second lead plate, and the first and second ceramic bodies.

【Claim 9】

The method according to claim 8, wherein the first connection part of the first lead plate is bent in a predetermined direction, and the second connection part of the first lead plate is bent in a direction opposite to that of the first connection part by longitudinally cutting an end of a long conductive plate to a predetermined length so as to divide the end into two parts which are the first and second connection parts of the first lead plate, and by bending the first connection part in a predetermined direction, and by bending the second connection part in a direction opposite to that of the first connection part.
[Claim 10]

The method according to claim 8, wherein the first connection part of the first lead plate is bent in a predetermined direction, and the second connection part of the first lead plate is bent in a direction opposite to that of the first connection part by forming the first lead plate using a mold constructed to form the first and second connection parts, which are bent in opposite directions.

[Claim 11]

The method according to claim 8, wherein a second end of the first lead plate and a second end of the second lead plate are bent to be in contact with an outer surface of the molding part by bending the second end of the first lead plate and the second end of the second lead plate.

[Claim 12]

The method according to claim 8, wherein a second end of the first lead plate and a second end of the second lead plate are bent to be in contact with an outer surface of the molding part by forming the first and second lead plates using a mold constructed to form the second end of the first lead plate and the second end of the second lead plate, which have bent shapes.
FIG. 3
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(Unit: mm)
FIG. 7
FIG. 8
FIG. 13
**INTERNATIONAL SEARCH REPORT**

### A. CLASSIFICATION OF SUBJECT MATTER

**IPC7 H01C 7/10**

According to International Patent Classification (IPC) or to both national classification and IPC

### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 H01C 7/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

- Korean Patents and applications for inventions since 1975
- Korean Utility models and applications for Utility models since 1975
- Japanese Utility models and application for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

- eKIPASS "SMD", "varistor", "lead", "plate", "ceramic"

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<td>A</td>
<td>US 5180387 A (Electromer Corp.) 23 Feb. 1993 See the whole document</td>
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<td>A</td>
<td>US 6252493 B1 (The Wiremold Company Brooks) 26 Jun. 2001 See the abstract</td>
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☐ Further documents are listed in the continuation of Box C.  
☒ See patent family annex.

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**Date of the actual completion of the international search**  
09 NOVEMBER 2005 (09.11.2005)

**Date of mailing of the international search report**  
09 NOVEMBER 2005 (09.11.2005)

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