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(54) Boost converter

(57) The invention provides a drive circuit for a capacitive load in which energy losses due to high-frequency spikes are prevented, when built into IC circuit boards.

Zener diodes are connected in series to the switching circuits connected between the negative terminal of the direct-current electrical source and the two sides of the capacitive load. Since these Zener diodes are in parallel with respect to the capacitive load, the flow of energy to the circuit board through the parasitic transistor structure of the Zener diodes is prevented. As a result, the loss of energy due to both electrical leaks and high-frequency spikes is eliminated.

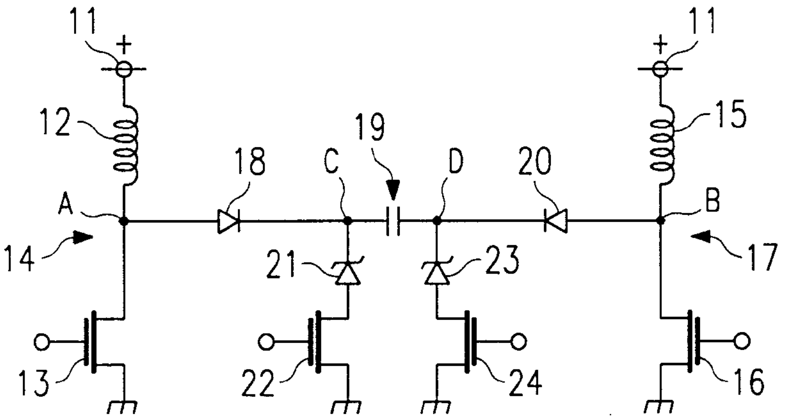

FIG. 2

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Description

This invention concerns drive circuits that drive capacitive loads such as electroluminescence panels (hereafter referred to as EL panels).

The type of drive circuit described above is well known from, for example, the detailed explanation of U. S. Patent fifth,349,269, and its structure is shown in Figure 1. As shown in Figure 1, the series circuit of the first coil (1a) and the first transistor (2a) is connected between the positive and negative terminals of the direct-current electrical source, and the connection point between this coil and transistor is joined to one terminal of the EL panel (5) by way of the first diode (3a) and the first Zener diode (4a). The connection point between the first Zener diode (4a) and one terminal of the EL panel (5) is grounded through the second transistor (6a). Also, the series circuit of the second coil (1b) and the third transistor (2b) is connected between the positive and negative terminals of the direct-current electrical source, and the connection point between this coil and transistor is joined to the other terminal of the EL panel (5) through the second diode (3b) and the second Zener diode (4b). The connection point between the second Zener diode (4b) and the other terminal of the EL panel (5) is grounded through the fourth transistor (6b).

A clock signal is applied to the gate of the first and third transistors (2a) and (2b), and gate signals that have opposite phases from one another are applied to the gates of the second and fourth transistors (5a) and (5b). As a result, a boosted voltage is applied between the terminals one and two of the EL panel (5).

With the widely known drive circuit described above, because the first and second Zener diodes (4a) and (4b) are connected to the current path between the first coil (1a) and the EL panel (5) and the current path between the second coil (2a) and the EL panel (5), these Zener diodes (4a) and (4b) serve the purpose of preventing electrical leaks from the direct-current electrical source. Consequently, when the second transistor (6a) is in a conductive state, the path through the positive terminal of the direct-current electrical source, the first coil (1a), the first diode (3a), the second transistor (6a), and the negative terminal is broken by the Zener diode (4a). When the fourth transistor (6b) is in a conductive state, the path through the positive terminal of the direct-current electrical source, the second coil (1b), the first diode (3b), the fourth transistor (6b), and the negative terminal is broken by the Zener diode (4b). As a result, through the action of these Zener diodes to prevent electrical leaks, the effect of greatly reducing the loss of energy is achieved.

However, when the above drive circuit is built into an IC circuit board, a parasitic transistor is formed in the structure of the Zener diode between it and said IC circuit board, and a high-speed, in other words a high-frequency, spike flows into the circuit board side through this parasitic transistor, and eventually flows to a ground [is grounded], with a resulting a loss of energy. When this type of energy loss occurs, the benefit of placing a Zener diode cannot be realized.

Consequently, the purpose of this invention is to present a drive circuit that will resolve the weaknesses described above, making it possible to greatly reduce the loss of energy, and enable the EL panel to produce light brightly over long periods of time.

The drive circuit for a capacitive load of this invention is connected between the positive and negative terminals of the direct-current electrical source, and is characterized by being equipped with a first serial branch circuit connected between the positive and negative terminals of a direct-current electrical source, and which has a first coil and a first switching element driven by a clock signal, which comprise a transformer, a second serial branch circuit connected between the positive and negative terminals of the above direct-current electrical source, and which has a coil and a second switching element driven by the above clock signal, which comprise a transformer, a first diode joined between the connection point of the first coil and the first switching element of the above first serial branch circuit, and one terminal of the capacitive load, a second diode joined between the connection point of the second coil and the second switching element of the above second serial branch circuit, and the other terminal of the above capacitive load, a serial branch circuit having a first Zener diode joined between the connection point of the above first diode and the capacitive load and the negative terminal of the above direct-current electrical source, and which has a threshold value larger than the source voltage of the direct-current electrical source, and a third switching element driven by a first gate signal with a duty ratio of 50%, and a serial branch circuit having a second Zener diode connected between the above second diode and the capacitive load, and which has a threshold value greater than the source voltage of the direct-current electrical source, and a fourth switching element driven by a second gate signal the opposite phase to the above first gate signal.

In this invention, Zener diodes are connected in parallel with respect to the capacitive load. If the Zener diodes are connected in parallel, along with the capacitive load, a type of integrated circuit is formed. Consequently, even if a high-frequency spike is produced by the electrical source, the spike takes on an integrated form; as a result, even if a drive circuit is formed on an IC circuit board, it is prevented from flowing into the circuit board through the parasitic transistor of the Zener diode. At the same time, since the Zener diodes are connected in series to the switching paths connected between the two terminals of the capacitive load and the negative terminal of the direct-current electrical source, the path from the electrical source to the negative terminal by way of these switching paths is broken by the Zener diodes, and electrical leaks are prevented. As a result, even when a drive circuit is formed onto an IC circuit board, it is possible to eliminate both the loss of energy from electrical leaks and the loss of energy from high-frequency spikes, making it possible to greatly increase the life of the direct-current electrical source.

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, and further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, in which:

Figure 1 is a circuit diagram that shows the structure of one example of an existing direct-current boost converter for driving an EL panel.

Figure 2 is a circuit diagram which shows the structure of a drive circuit for a capacitive load according to this invention.

Figure 3 is a signal waveform diagram for explaining the operation of the drive circuit shown in Figure 2.

Figure 4 is a circuit diagram that shows the structure of a variation of the drive circuit for driving the EL panel according to this invention.

Figure 5 is a signal waveform diagram for explaining the operation of the drive circuit shown in Figure 4.

Figure 2 is a circuit diagram showing the structure of one application example of the drive circuit for a capacitive load according to this invention. The first serial branch circuit (14), in which the first coil (12) and the first switching transistor (13) are connected in series, is connected between the positive terminal (11) of the direct-current electrical source and the grounded negative terminal. In the same way, the second serial branch circuit (17), in which the second coil (15) and the second switching transistor (16) are connected in series, is connected between the positive terminal (11) of the direct-current electrical source and the negative terminal. The connection point (A) of the first coil (12) and the first switching transistor (13) of the first serial branch circuit (14) is joined to one terminal of the EL panel (19) through the first diode (18), and the connection point (B) of the second coil (15) and the second switching transistor (13) of the second serial branch circuit (17) is joined to the other terminal of the EL panel (19) through the second diode (20). The connection point (C) of the cathode of the first diode (18) and the EL panel (19) is grounded through the first Zener diode (21), which is a constant-voltage element, and the third switching transistor (22); the connection point (D) between the cathode of the second diode (20) and the EL panel (19) is grounded through the second Zener diode (23) and the fourth switching transistor (24). The cathodes of these first and second Zener diodes (21) and (23) are connected in the direction of the EL panel, and their threshold voltage is made higher than that of the source voltage of the direct-current electrical source.

Figure 3 shows the waveform of the signal applied to the gate of the switching transistor of the drive circuit described above.

Figure 3A shows the clock signal applied to the gates of the first and second switching transistors.

Figure 3B shows the gate signal (V2) applied to the gate of the fourth switching transistor.

Figure 3C shows the gate signal (V3) applied to the gate of the third switching transistor, and its phase is the opposite of the gate signal in Figure 3B.

As a clock signal (V1) is applied to the gate of the switching transistor (13) of the first serial branch circuit (14), and the gate signal (V2) is applied to the gate of the third switching transistor (22), they go into the off position; as the gate signal (V3) is applied to the gate of the fourth switching transistor (24), it goes into the on position. In this case, the voltage at connection point (A) gradually increases as shown in Figure 3D, and this is applied to the EL panel (19). In this case, the voltage at connection point (D) is roughly zero, and at connection point (C) it is positive.

Next, the fourth switching transistor (24) goes into the off position, and the third switching transistor (22) goes into the on position. In this state, the voltage at connection point (B) gradually increases to 120 V, as shown in Figure 3E, and this boosted voltage is applied to the EL panel (19). In this case, the connection point (C) is roughly at zero, but the voltage at connection point (D) is positive. As a result, since a drive voltage that reciprocates in polarity is applied to the EL panel (19), the efficiency of light emission of the EL panel is high.

Next the prevention of electrical leaks will be explained. The third switching transistor (22) is in the off position, and the fourth switching transistor (24) is in the on position. In the case of the widely known drive circuit shown in Figure 1, when looked at from the electrical source side, since the Zener diodes are connected to the EL panel in series, when a high-frequency spike, in other words high-speed energy, is supplied in the direction of the EL panel from the electrical source, the energy flows into the circuit board through the parasitic transistor peculiar to the Zener diode, causing a loss of energy. In contrast, with the drive circuit shown in Figure 2, since the Zener diode (21) is in a parallel position with respect to the EL panel (19), a type of integrated circuit is formed. Consequently, the high-frequency spike takes on an integrated form; as a result, it is prevented from flowing into the circuit board through the parasitic transistor.

Also, the path through the positive terminal (11), the second coil (15), connection point (B), the second diode (20), connection point (D), the second Zener diode (23), and the fourth switching transistor is cut off from the low voltage current from the direct-current electrical source by the Zener diode (23), preventing electrical leaks through this path.

Figure 4 is a circuit diagram that shows the structure of a modified example of the drive circuit according to this invention. The first serial branch circuit (24), in which the first and second switching transistors (22) and (23) are connected in series, is connected in parallel to the second serial branch circuit (27), in which the third and fourth switching transistors (25) and (26) are connected in series, between negative terminals grounded to DC positive terminal (21). The coil (28) is joined between connection point (A) of the first and second switching transistors (22) and (23) of the first serial branch circuit (24) and connection point (B) of the third and fourth switching transistors (25) and (26) of the second serial branch circuit (27).

Furthermore, the above connection point (A) is joined to one terminal of the EL panel (31) through the first diode (29), and connection point (B) is joined to the other terminal of the EL panel through the second diode (30). The connection point (C) of the cathode of the first diode (29) and one terminal of the EL panel (31) is grounded through the first Zener diode (32) and the fifth switching transistor (33). The connection point (D) of the cathode of the second diode (30) and the other terminal of the EL panel (31) is grounded through the second Zener diode (34) and the sixth switching transistor (35).

Figure 5 shows the waveform of the signal applied to the gate of the switching transistor of the drive circuit described above.

Figure 5A shows the clock signal (V1) applied to the gate of the first switching transistor (22) of the first direct-current branch circuit (24); in this example, its amplitude is 5 V, the repetition frequency is 8 KHz, and the duty cycle is 3:1. Also, the voltage of the direct-current electrical source is 3 V.

Figure 5B shows the gate signal (V2) applied to the gate of the second switching transistor (23), where its amplitude is 5 V, and its repetition frequency is 512 Hz.

Figure 5C shows the clock signal applied to the gate of the third switching transistor (25) of the second direct-current branch circuit (27).

Figure 5D shows the gate signal applied to the gate of the fourth switching transistor (26) of the second direct-current branch circuit (27); its phase is the opposite of the gate signal shown in Figure 5B.

Again, a gate signal, which is the same as the gate signal (V2) applied to the gate of the second switching transistor (23) described above, is applied to the gate of the fifth switching transistor (32); a gate signal, which is the same as the gate signal (V4) applied to the gate of the fourth switching transistor (26) described above, is applied to the gate of the sixth switching transistor (33).

The first clock signal (V1) is applied to the gate of the first switching transistor (22) of the first direct-current branch circuit (24), and the second switching transistor (23) goes into the off position because of the first gate signal (V2) applied to the second switching transistor (23). In this case, the third switching transistor (25) of the second direct-current branch circuit (27) is in the off position, but the fourth switching transistor (26) is in the on position, and while the fifth switching transistor (32) is in the off position, the sixth switching transistor (33) is in the on position. As a result, the voltage at connection point (A) gradually increases as shown in Figure 5E; this is applied to the EL panel (31). In this case, the electrical potential at connection point (D) is zero, but the voltage at connection point (C) will be positive. In this case the maximum value of the drive voltage is 120 V.

Next, the first gate signal (V2) applied to the gate of the second switching transistor (23) of the first direct-current branch circuit (24) rises to a high level; this transistor goes on, and in a condition where the second clock signal (V3) is applied to the gate of the third switching transistor (25) of the second direct-current branch circuit (27), the first switching transistor (22) of the first direct-current branch circuit (24) and the fourth switching transistor (26) of the second direct-current branch circuit (27) both go into the off position. In addition, the fifth switching transistor (32) turns on, while the sixth switching transistor (26) turns off. In this state, the voltage at connection point (B) will gradually increase to 120 V as shown in Figure 5F; this is applied to the EL panel (31). In this case, since the fifth switching transistor (32) is in the on position, the electrical potential at connection point (C) is zero, but the voltage at connection point (D) is positive.

With the drive circuit of this example as described above, it is possible for electrical leaks to be effectively prevented by the first and second Zener diodes connected in parallel with respect to the EL panel (31). In fact, since a drive voltage that reciprocates in polarity is applied to the EL panel (31), which is a capacitive load, the efficiency of light emission is high, and even with a low direct-current source voltage, it is possible for the EL panel to produce light brightly over long periods of time. Also, since only one coil is used, the structure of the EL panel is simple, and it is possible to keep costs low.

This invention need not be limited to the application example described above, and many variations and changes are possible. For example, with the above application example, a MOS-type field effect transistor was used as the switching element, but a bipolar transistor may also be used. Furthermore, with the above application example, an EL panel was driven as the capacitive load, but other capacitive loads may also be driven.

With the invention as described above, since Zener diodes are connected in series to the switching circuits connected to both sides of the capactivie load, it is possible to eliminate both the electrical leaks that flow through these circuits and the energy loss that flows into the IC circuit board through the parasitic transistor structure.

Claims

1. A drive circuit for a capacitive load, characterized by being equipped with a first serial branch circuit connected between the positive and negative terminals of a direct-current electrical source, and which has a first coil and a first switching element driven by a clock signal, comprising a transformer,

a second serial branch circuit connected between the positive and negative terminals of the above direct-current electrical source, and which has a coil and a second switching element driven by the above clock signal, comprising a transformer, a first diode joined between the connection point of the first coil and the first switching element of the above first serial branch circuit, and one terminal of the capacitive load, a second diode joined between the connection point of the second coil and the second switching element of the above second serial branch circuit, and the other terminal of the above capacitive load, a serial branch circuit having a first Zener diode joined between the connection point of the above first diode and the capacitive load and the negative terminal of the above direct-current electrical source, and which has a threshold value larger than the source voltage of the direct-current electrical source, and a third switching element driven by a first gate signal with a duty ratio of 50%, and a serial branch circuit having a second Zener diode connected between the above second diode and the capacitive load, and which has a threshold value greater than the source voltage of the direct-current electrical source, and a fourth switching element driven by a second gate signal having the opposite phase to the above first gate signal.

2. A drive circuit for a capacitive load, characterized by being equipped with a first direct-current branch circuit having a first switching element connected between the positive and negative terminals of the direct-current electrical source, and which is driven by the first clock signal, and a second switching element having a frequency higher than the first clock signal, with a duty ratio of 50%, a second direct-current branch circuit having a third switching element connected between the positive and negative terminals of the above direct-current electrical source, and which is driven by the second clock signal, and a fourth switching element driven by a second gate signal having the opposite phase to the above first clock signal, a coil joined between the first connection point of the first and second switching elements of the above first direct-current branch circuit, and the second connection point of the third and fourth switching elements of the above second direct-current branch circuit, a first diode joined between the above first connection point and one terminal of the capacitive load, a second diode joined between the above second connection point and the other terminal of the capacitive load, a first Zener diode joined between the third connection point of the above first diode and one terminal of the capacitive load and the negative terminal of the above direct-current electrical source, and which has a threshold value that is greater than the source voltage of the

3. The drive circuit for the capacitive load of claim 1 or claim 2, characterized by the capacitive load being an electrical field light-emitting element.

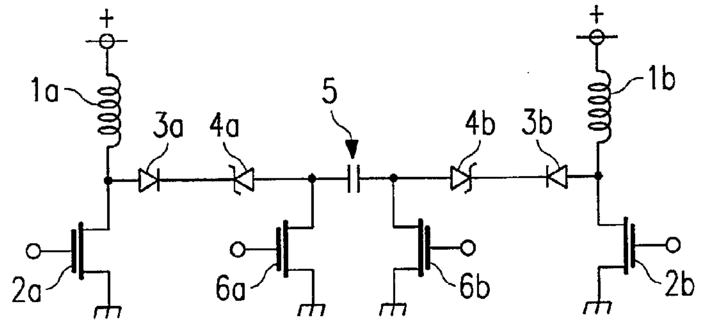

FIG. 1
(PRIOR ART)

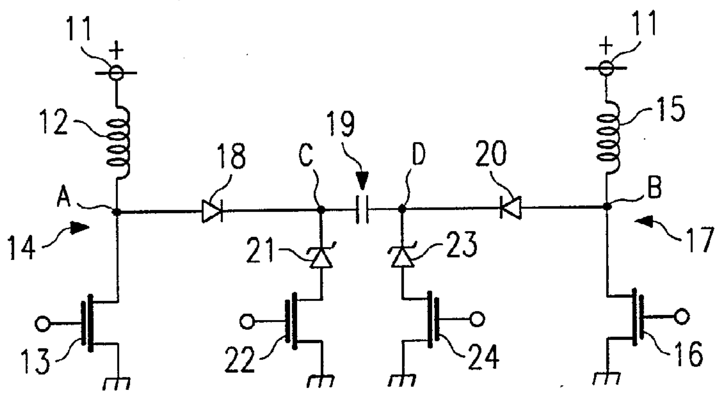

FIG. 2

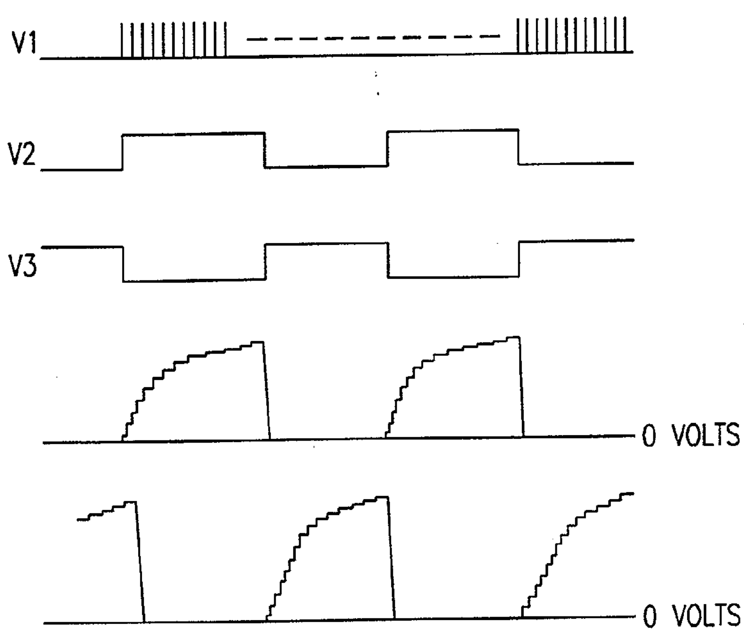

FIG. 3A
FIG. 3B
FIG. 3C
FIG. 3D
FIG. 3E

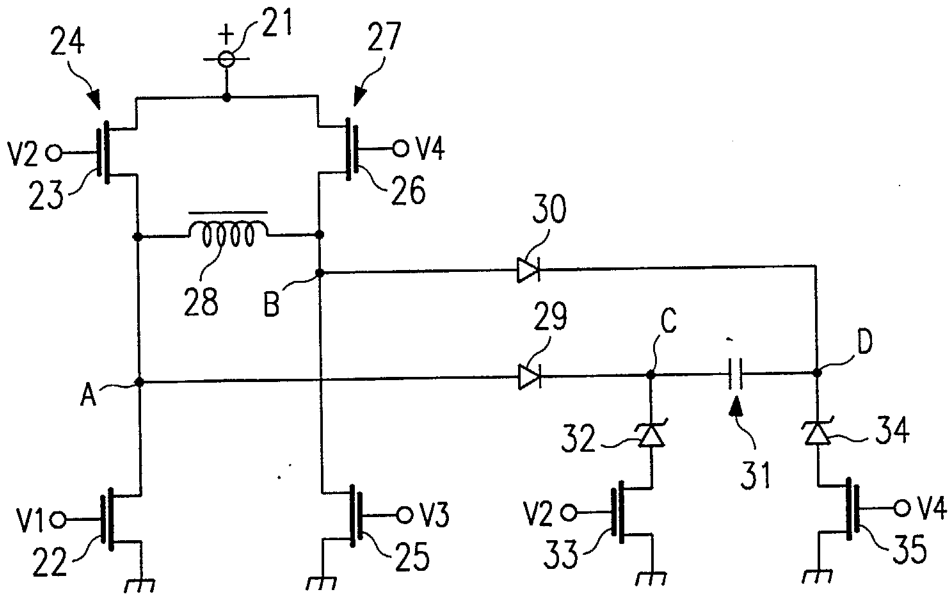

FIG. 4

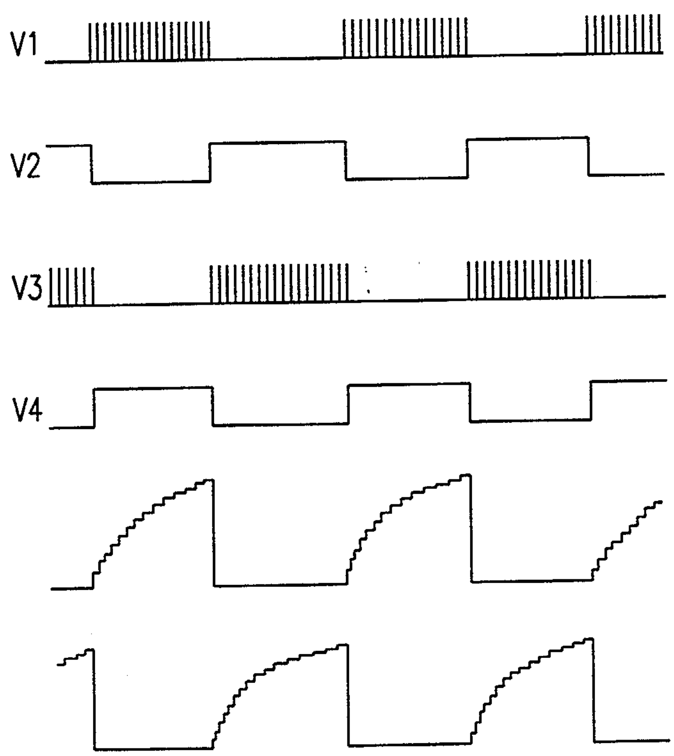

FIG. 5A

FIG. 5B

FIG. 5C

FIG. 5D

FIG. 5E

FIG. 5F

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 8396

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y,D	US 5 349 269 A (KIMBALL ROBERT A) 20 September 1994 * column 6, line 23 - column 6, line 32; figures 3,7 * ---	1,3	H05B33/08
Y,P	US 5 502 357 A (KIMBALL ROBERT A) 26 March 1996 * column 6, line 37 - column 6, line 64; figure 8 * -----	1,3	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 February 1997	Speiser, P

CATEGORY OF CITED DOCUMENTS

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