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(54) **Electric outboard drive system**

(57) An electric outboard drive system for a watercraft (1) has a support casing fastenable on a hull (2). Further, an electric drive unit (6) is disposed at the lower part of the support casing and a control unit (7) is disposed at the upper part of the support casing for controlling the electric motor drive unit. In this system, electric components generating a large amount of heat during operation are disposed within the electric drive unit (6) and electric components generating a comparable smaller amount of heat during operation are disposed in the control unit (7).

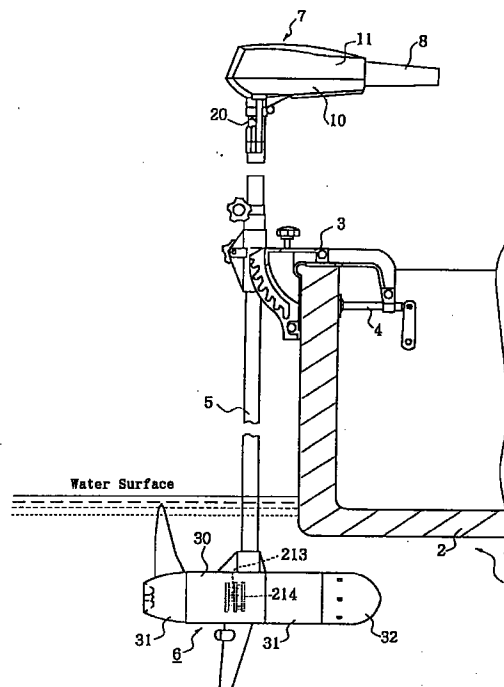


FIGURE 1

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Description

The present invention relates to an electric outboard drive system for a Watercraft having a support casing fastenable on a hull, an electric drive unit disposed at the lower part of the support casing, and a control unit disposed at the upper part of the support casing for controlling the electric motor drive unit.

Small watercrafts include for instance a type in which a support cylinder is supported on the hull, an electric motor drive unit of an electric outboard motor is disposed at the lower part of the support cylinder, and a control unit for controlling the electric motor drive unit is disposed in an upper case of the support cylinder.

In small watercrafts, the conductive wire for interconnecting the electric motor drive unit and the control unit must have a large cross-sectional area to conduct a large amount of current such as 10 A. Conventionally, electric connections are made using wires having greater flexibility so that wire connection work may be carried out within a narrow space of the electric motor drive unit through printed circuit board.

In order to increase the output of the electric outboard drive system, the number of electric components which generate a large amount of heat for controlling the electric motor drive unit increases and they cannot be housed inside the electric motor drive unit and this poses a certain limit to the increase in the output of the electric motor drive unit.

When the output of the electric outboard motor drive system is increased, the number of components increases, the size of the electric motor drive unit increases, and the increased diameter of the electric motor drive unit increases resistance in the water and manufacturing cost.

Power elements are used to control the rotation of the electric outboard motor. In order to increase the output, the number of the power elements must be increased. When the layout of the increased number of power elements is made in the conventional way, the diameter of the electric motor drive unit must be increased, which increases resistance in the water and manufacturing cost.

In the conventional products, a printed circuit board on which power elements are mounted is directly attached to the inside of the electric motor drive unit so that heat is dissipated. When the number of the power elements is increased to increase the output, they cannot be mounted in the same manner and the printed circuit board on which power elements are mounted cannot be directly attached to the inside of the electric motor drive unit.

When the thick wire for interconnecting the electric motor drive unit and the control unit is chosen on the ordinary cost basis, a wire coated with vinyl will be the choice. Such a wire has a rigidity and is hard to bend, which is not practical for doing connection work in a narrow space. In order to connect a wire having a rigidity and a wire having a high flexibility together, the wire

ends require soldering process so that they can be easily inserted in the holes in the printed circuit board. For the printed circuit board of several tens of amperes for instance, a large space on the printed circuit board is taken up for the large amount of current, and solder cladding is required.

Accordingly, it is an objective of the present invention to provide an improved electric outboard drive system as indicated above, which facilitates with simple technical means to reliably increase the output and simultaneously to minimize the size and dimensions.

According to the present invention, this objective is solved for an electric outboard drive system as indicated above in that electric components generating a large amount of heat during operation are disposed within the electric drive unit and electric components generating a comparable smaller amount of heat during operation are disposed in the control unit.

In this way, the electric components generating a large amount of heat are disposed within the underwater electric motor drive unit while other components generating a small amount of heat are separately disposed within the control unit above the water so that the electric motor drive unit is made compact as a whole while securing cooling performance for the electric components generating a large amount of heat.

According to another embodiment of the invention, the electric outboard motor comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a plural number of printed circuit boards are disposed within the electric motor drive unit with conductive spacers interposed among the printed circuit boards so that electric current may be applied to electric components disposed on the plural number of printed circuit boards.

In this way, the distances among the plural number of printed circuit boards are held to a constant value with the conductive spacers, electric current may be applied to the electric components disposed on the plural number of printed circuit boards, the plural number of printed circuit boards are disposed in a narrow space within the electric motor drive unit, ease of assembly is improved, and the amount of wiring is reduced.

With a further embodiment of the invention, the electric outboard motor comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a plural number of printed circuit boards are disposed within the electric motor drive unit, a circuit pattern on one printed circuit board is bent and erected on the printed circuit board and the circuit pattern is electrically connected to a circuit pattern of another printed circuit board.

In this way, the circuit pattern on one printed circuit

board is bent and rected on the printed circuit board and electrically connected to the circuit pattern on another printed circuit board so that a plural number of printer circuit boards are disposed in a narrow space within the electric motor drive unit, ease of assembly is improved, and the amount of wiring is reduced.

Further, according to another embodiment of the invention, the electric outboard motor comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a heat sink on which electric components generating a large amount of heat are mounted and a printed circuit board are disposed within the electric motor drive unit, and the printed circuit board is attached through a spacer to the electric components generating a large amount of heat.

In this way, the heat sink on which the electric components generating a large amount of heat are mounted, and the printed circuit board are disposed within the electric motor drive unit, and the printed circuit board is attached through spacers to the electric components generating a large amount of heat so that vibration to the electric components generating a large amount of heat is reduced, and the distance between the printed circuit board and the heat sink is held constant.

According to a still further embodiment of the invention, the electric outboard motor comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a printed circuit board is disposed within the electric motor drive unit and a power element is disposed on the printed circuit board so as to surround the electric motor drive shaft.

In this way, a large number of power elements are disposed in a narrow space around the electric motor drive shaft with the legs of the power elements directed in the same direction so that the circuit pattern routing is made efficiently and space is saved on the printed circuit board.

According to another embodiment of the invention, the electric outboard motor comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a heat sink is disposed within the electric motor drive unit from the direction of the electric motor drive shaft and secured on the inside cylindrical surface.

In this way, the heat sink is inserted from the direction of the electric motor drive shaft into the inside of the electric motor drive unit and secured to the cylindrical surface so that attachment of a single electric component generating a large amount of heat is possible after

it is assembled to the heat sink, ease of assembly is improved, and the heat dissipation route is secured.

According to a further embodiment of the invention, the electric outboard motor comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that part of a portion, disposed within the electric motor drive unit or within the control unit, of a wire interconnecting the electric motor drive unit and the control unit is adapted to have a greater flexibility.

In this way, part of the portion of the wire disposed within the electric motor drive unit or within the control unit is made to be more flexible with the flexibility of the wire appropriately changed according to the location where the wire is disposed so that the wiring is made at a relatively low cost while securing ease of the wiring work in a narrow space.

Small watercrafts include for instance a type in which a support cylinder is supported on the hull, an electric motor drive unit of an electric outboard motor is disposed at the lower part of the support cylinder, and a control unit for controlling the electric motor drive unit is disposed in an upper case of the support cylinder.

In small watercrafts, the conductive wire for interconnecting the electric motor drive unit and the control unit must have a large cross-sectional area to conduct a large amount of current such as 10 A. A printed circuit board on which electric components are provided for controlling the electric motor drive unit is disposed in the control unit.

With the small watercrafts, water may enter the inside of the control unit. Therefore, measures should be taken to prevent the printed circuit board from being wet with water even if water enters the inside of the control unit.

To increase the output of the electric motor drive unit, the number of electric components for controlling the electric motor drive unit is increased. Those electric components generate large amount of heat and not all of them may be accommodated in the electric motor unit. Therefore, there is a certain limit to the increase in the output of the electric motor drive unit.

Therefore, electric components which generate large amount of heat are mounted on the printed circuit board in the control unit and those electric components must be cooled efficiently. It is conceivable to mount the electric components directly on an aluminum case so that the electric components are cooled. However, when the electronic components are mounted directly on the case, attachment work for the printed circuit board, wiring, and assembling becomes difficult.

A heat sink is provided for dissipating the large amount of heat generated by the electric components. However, the heat sink as an independent part is placed on the printed circuit board and takes up a large space.

Still another problem is that a control section and a power section are separately disposed on a large

printed circuit board. In that case for example, a current sensor is disposed in the control section while a current detection circuit is disposed in the power section. Therefore, thick pattern is drawn to the control section to take up a large area wastefully on the printed circuit board in the control section.

Still another problem for example is that a large current circuit is connected to a current sensor to detect the current of the circuit. Because of the large amount of current, connection terminals are large, and therefore, terminals are crimped after passing through wires. The terminal crimping work during the assembly process is inefficient. Since the crimping work is done after the wire has been passed to the sensor, the work is done manually and as a result, the quality is unstable.

The aspect of an embodiment of the invention made in view of the problems described above is to provide a controller for an electric outboard motor to accomplish the following objects. One aspect of the invention is to facilitate attachment and removal of the printed circuit board and to prevent the printed circuit board from being wetted with water. Another aspect of the invention is to efficiently cool the electric components which generate a large amount of heat. A further aspect of the invention is to simplify the work of mounting the electric components on the printed circuit board and simplify the work of assembling the printed circuit board. Another aspect of the invention is to provide an assembly structure to rationally dispose electric components. Still another aspect of the invention is to simplify the work of mounting the electric components on the printed circuit board and simplify the work of assembling the printed circuit board. A still further aspect of the invention of claim 6 is to eliminate the preliminary terminal crimping work from the assembly process and to make it possible to connect wires in the assembly process.

To solve the problems and accomplish the aspects described above, the invention provides a printed circuit board that is disposed at a location which is within a space between upper and lower cases of the control unit, separated from the bottom of the lower case, and above the mating surfaces of the upper and lower cases.

Advantageously, it is possible that a heat sink is brought in tight contact with the underside surface of the printed circuit board and the electric components generating a large amount of heat are mounted on the heat sink. Large amount of heat generated from the electric components is absorbed with the heat sink and dissipated through the printed circuit board to the case. Thus the electric components generating large amount of heat are cooled efficiently.

According to a preferred embodiment of the invention, the electric outboard drive system comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor

drive unit, characterized in that the case of the control unit is made of a metal and formed with integral ribs to which a heat sink for mounting electric components generating large amount of heat is attached. Since the control unit case is made of metal and the heat sink is in direct contact with the ribs, large amount of heat from the heat sink on which the electric components are mounted is dissipated to the metallic case. Additional advantages are that the heat sink may be attached easily to secure a heat dissipation route, the electric components generating large amount of heat on the heat sink have a large degree of freedom in layout, and ease of assembling the printed circuit board and attaching the printed circuit board assembly is improved while securing the cooling performance of the electric components generating large amount of heat.

Further, it is possible for an electric outboard drive system comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a large current printed circuit board through which a large amount of current flows and a control printed circuit board on which a CPU is mounted are separately disposed within the control unit. Advantages are that both of the large current printed circuit board and the control printed circuit board are reasonably disposed separately, the circuit through which the large amount of current flows is short with a minimum length, and wire routing to the control printed circuit board is unnecessary.

In addition, it is advantageous that the electric outboard drive system comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a heat sink for mounting electric components generating large amount of heat is disposed within the control unit case, another heat sink is disposed outside the case, and the internal and external heat sinks are interconnected. The interconnection secures a heat dissipation route. Additional advantages are that a certain degree of freedom is provided for the layout of the electric components generating large amount of heat on the heat sink, for the layout of the electric components within the case, and ease of assembling the printed circuit board is improved while securing the cooling performance for the electric components generating large amount of heat.

Moreover, it is advantageous when the electric outboard drive system comprising a support cylinder supported on a hull, an electric motor drive unit disposed at the lower part of the support cylinder, and a control unit disposed at the upper part of the support cylinder so as to control the electric motor drive unit, characterized in that a large current printed circuit board through which a large amount of current flows is disposed within the con-

trol unit, a current sensor for detecting electric current is disposed on the large current printed circuit board, and the large current printed circuit board is provided with a portion for soldering a wire coming from the electric motor drive unit through the current sensor and with a terminal to which the wire may be connected. Usually a thick wire has to be passed through the current sensor for detecting a large amount of current, and usually a terminal is crimped to the wire. However, because of the large size of the terminal, the wire to which the terminal is crimped often cannot be passed through the current sensor. With this invention, however, since the portion for soldering the wire passed through the current sensor and the terminal for screw-stopping the wire coming from the electric motor are provided on the large current printed circuit board, the preliminary terminal crimping step is eliminated from the assembly process and thus ease of assembly is improved as the wire connection is made in the assembly process.

Moreover, small watercrafts include those on which an electric outboard drive system is mounted which comprises a control unit for controlling the electric drive unit, so that the drive of the propeller is controlled with the control unit.

For instance, if the propeller of the electric outboard motor is overloaded as with tangled weeds or the like during running, the electric motor for driving the propeller and the electric components may be damaged by overheating. Therefore, there are some arrangements in which the temperatures of the electric components are detected to turn off the electric power and stop the electric motor for driving the propeller.

With the arrangement described above in which the temperatures of the electric components are detected to turn off the electric power when the electric motor is overloaded, the electric motor of the electric outboard motor remains stopped unless the temperatures of the heated electric components return to a safety range, and sometimes the tangled weeds cannot be unravelled.

The drive of the electric motor is made by rotating the accelerator grip from the neutral position in both forward and reverse directions, and the accelerator signal output is obtained through changes in the resistance of the resistor. The resistance is the maximum in the neutral position and decreases in both forward and reverse directions. The electric motor is stopped at the neutral position with the resistance at the maximum, and the output of the electric motor driving output is increased for both forward and reverse movements of the accelerator. In such an arrangement in which the maximum resistance of the resistor occurs at the neutral position, variation in speed is large at very low speeds, and handling is not easy. Because of the large variation in the resistance value, accelerator characteristics varies largely and adjustment work is required.

A potentiometer as a speed control means operated with the accelerator grip is attached to a bent portion of an attachment stay or to a separately welded

attachment part, and wires are soldered to the terminals of the potentiometer. However, the soldering must be done before the attachment stay is secured in position; otherwise the attachment stay stands in the way of the soldering work.

In some models of the electric outboard motor, additional batteries are connected in series to increase output. In that case, it is necessary to take care that the system is not damaged.

The electric outboard motor has another problem: If the electric power source is interrupted as the battery vibrates during running, a reset signal enters the CPU, which causes the program to carry out an initialization process. If the accelerator is open at this time, the electric motor is undesirably stopped.

Another possible problem arises from the use of a large capacity electrolytic condenser used as a smoothing condenser in the electric outboard motor. That is to say, when the condenser is connected to the battery, a closing current flows into the condenser and undesirable sparks may occur between contact points.

Therefore, another aspect of this invention made in view of the above is to provide a controller for an electric outboard drive system capable of protecting the control system of the electric outboard motor and providing excellent operation performance.

To solve the problems and accomplish the aspects described above, the controller or control unit is provided with

motor current detection means for detecting the current to the electric motor of the electric outboard motor when the current is not less than a specified value,

electric motor stopping means for stopping the electric motor when the electric motor is in an overloaded state in which the current is not less than the specified value, and

electric motor control means for releasing the stop of the electric motor by setting an accelerator from the overloaded state to the neutral state.

When the electric motor current is not less than the specified value, the electric motor is stopped to protect a system including the electric motor, power semiconductors, etc. from being damaged. Actually in most cases, the overcurrent state is caused by weeds tangled around the propeller. However, the work for a user to lift the weeds above the water and remove them is very cumbersome. With this invention, however, it is arranged that the stop of the electric motor is released by operating the accelerator from the overcurrent state to the neutral position, the electric motor is operated for a specified period of time when the accelerator is opened again. That is to say, the overcurrent state is released only when the accelerator is set to the neutral position, and the electric motor is operated only for a short period of time when the accelerator is opened again. This makes it possible to apply power to the pro-

propeller for a short period of time so that the electric motor is protected, weeds tangled around the propeller can be unraveled, and the ease of use by the user is improved.

According to another embodiment of the invention, the controller is provided with

electric motor current detection means for detecting the current to electric components of the electric motor when the current is not less than a specified value,

electric motor stopping means for stopping the electric motor in an overloaded state in which the detected current to the electric components is not less than a specified value, and

electric motor control means for performing the steps of,

releasing the stop of the electric motor by operating the accelerator from the overloaded state to the neutral state,

driving the electric motor for a specified period of time when the accelerator is opened again, and stopping the electric motor.

When the detected current of the electric components is not less than the specified value, the electric motor is stopped to protect a system including the electric motor, power semiconductors, etc. from being damaged. Actually in most cases, the overload state is caused by weeds tangled around the propeller. However, the work for a user to lift the weeds above the water and remove them is very cumbersome. With this invention, however, it is arranged that the stop of the electric motor is released by operating the accelerator from the overload state to the neutral position, the electric motor is operated for a specified period of time when the accelerator is opened again. That is to say, the overload state is released only when the accelerator is set to the neutral position, and the electric motor is operated only for a short period of time when the accelerator is opened again. This makes it possible to apply power to the propeller for a short period of time so that the electric motor is protected, weeds tangled around the propeller can be unraveled, and the ease of use by the user is improved.

According to a further embodiment of the invention, the controller is provided with,

temperature detection means for detecting the temperature of the electric components of the electric motor,

electric motor stopping means for stopping the electric motor when the detected temperature is not less than a specified value, and

electric motor control means for performing the steps of,

releasing the stop of the electric motor by operating the accelerator from the overheated state in which the temperature is not less than the specified value to the neutral state,

driving the electric motor for a specified period of time when the accelerator is opened again, and stopping the electric motor.

When the detected temperature of the heat generating electric components is not lower than a specified value, the electric motor is stopped and protected. Furthermore, it is possible to release the stop of the electric motor by operating the accelerator from the overheat state in which the temperature is not lower than the specified value to the neutral state, to drive the electric motor for a specified period of time and stop it when the accelerator is opened again. That is to say, the stop of the electric motor is released by a simple accelerator operation and the electric motor is returned to the initial state.

According to a still further embodiment of the invention, the controller is provided with,

acceleration input means for obtaining acceleration input in proportion to movements of the accelerator from the neutral position to forward and reverse directions,

acceleration output means for obtaining from the acceleration input acceleration output of quadratic function characteristic with its origin at the neutral position, and

electric motor control means using the acceleration output of the quadratic function characteristic for stopping the electric motor by setting the accelerator to the neutral position, operating the electric motor in the normal rotating direction by forward movement of the accelerator, and in the reverse rotating direction by the reverse movement of the accelerator.

The acceleration output of the quadratic function characteristic with the neutral position at the origin is obtained from the acceleration input which is in proportion to the movement of the accelerator in both forward and reverse directions from the neutral position. The acceleration output of the quadratic function characteristic is used to stop the electric motor with the accelerator at the neutral position, to operate the electric motor in the normal rotating direction with the accelerator operated in the forward direction, and in the reverse rotating direction with the accelerator operated in the reverse direction. Thus, the quadratic characteristic feeling is obtained simply at a low cost, ease of use at very low speeds is improved, and man-hour is reduced as adjustment of the accelerator characteristic is unnecessary.

It is advantageous when the controller is provided with,

an attachment stay with part of it having a punched hole and a bent and erected attachment stay having an attachment portion,

speed control means operated with an accelerator

and attached to the attachment portion, and
a speed control wire passed through the punched
hole of the attachment stay and connected by sol-
dering to the speed control means.

The speed control means is attached to the attach-
ment portion of the attachment bracket, the wire is
passed through the punched hole of the attachment
stay, the attachment stay does not stand in the way of
the soldering connection to the speed control means.
That is to say, ease of attaching and soldering the wire
is improved with a simple structure of the attachment
stay even after the attachment of the speed control
means, and degree of freedom is provided to the proc-
ess.

Further, it is possible that the controller is provided
with,

battery voltage detection means for detecting the
voltage of the battery of the electric outboard motor
when it is connected,

electric motor start prohibiting means for prohibiting
the start of the electric motor when the battery volt-
age is not less than a specified value, and
start prohibition releasing means for releasing the
stop of the electric motor by disconnecting the bat-
tery.

According to a still further embodiment of the inven-
tion, the controller is provided with,

a time constant circuit provided in the control power
source circuit of the electric outboard motor,
voltage detection means for detecting the voltage of
the time constant circuit, and
control means for continuing the operation of the
electric outboard motor only when the detected
voltage of the time constant circuit is not less than
the specified value and control information is nor-
mal.

The voltage of the time constant circuit provided in
the control power source circuit of the electric outboard
motor is detected. The operation of the electric outboard
motor is continued only when the detected voltage of
the time constant circuit is not less than the specified
value and the control information is normal. When the
control power source is interrupted, the system is reset
to perform initialization process. Here, the problem of
undesirable stop of the electric outboard motor when
the accelerator is open is eliminated. The operation of
the electric motor is continued with the previous opera-
tion mode only when control information is not
destroyed.

The voltage of the time constant circuit provided in
the control power source circuit of the electric outboard
motor is detected. The operation of the electric outboard
motor is continued only when the detected voltage of
the time constant circuit is not less than the specified

value and the control information is normal. When the
control power source is interrupted, the system is reset
to perform initialization process. Here, the problem of
undesirable stop of the electric outboard motor when
the accelerator is open is eliminated. The operation of
the electric motor is continued with the previous opera-
tion mode only when control information is not
destroyed.

According to another embodiment of the invention,
the controller is provided with,

a power source circuit having an electrolytic con-
denser for the electric outboard motor,
a delay circuit for delaying the charging of the elec-
trolytic condenser,
a short circuit for preventing an electric current from
flowing to the delay circuit in normal state, and
a time constant circuit for closing the short circuit
when the electrolytic condenser is sufficiently
charged.

A large capacity electrolytic condenser is used as a
smoothing condenser to smooth the rotating operation
of the electric motor. Therefore, in the normal state,
electric current is prevented from flowing to the delay
circuit to delay the charging of the electrolytic con-
denser. When the electrolytic condenser is charged suf-
ficiently, the the- short circuit is closed to prevent a
closing current from flowing to the electrolytic con-
denser, to prevent a fire from occurring, and to prevent
a user from being startled by the spark occurring when
the user connects the battery.

In the following, the present invention is explained
in greater detail with respect to several embodiments
thereof in conjunction with the accompanying drawings,
wherein:

FIG. 1 is a view of a watercraft on which the electric
outboard motor is mounted;

FIG. 2 is a view of the control unit;

FIG. 3 is a view of an electric motor drive unit;

FIG. 4 is a cross-sectional view of the layout of the
printed circuit board of the electric motor drive unit;

FIG. 5 is a cross-sectional view taken along the line
V-V in FIG. 4;

FIG. 6 is a cross-sectional view taken along the line
VI-VI in FIG. 4;

FIG. 7 is a left side view of the drawing of FIG. 4;

FIG. 8 is an enlarged view of the control assembly
(C);

FIGs. 9(a) and 9(b) are plan views of the printed cir-
cuit boards (54) and (55);

FIG. 10 is an enlarged view of the control assembly
(C);

FIG. 11 is a plan views of the printed circuit board
(54);

FIG. 12 is a plan views of the printed circuit
board(55);

FIG. 13 is a cross-sectional view taken along the

line XIII-XIII in Fig. 12;

FIG. 14 is an enlarged view of the control assembly (C);

FIG. 15 is an enlarged view of the control assembly (C);

FIG. 16 is a plan view of the wiring surface of the printed circuit board (54);

FIG. 17 is a plan view of the wiring surface of the printed circuit board (55);

FIG. 18 is a plan view of the solder surface of the printed circuit board (54);

FIG. 19 is a plan view of the solder surface of the printed circuit board (55);

FIG. 20 is a rough view of a wire construction;

FIG. 21 is a view seen from the direction (E) in FIG. 20;

FIG. 22 is a view of a grommet;

FIG. 23 is a view of the control unit;

FIG. 24 is a view of a printed circuit board assembly;

FIG. 25 is a view of a large current printed circuit board;

FIG. 26 is a view of another embodiment of a printed circuit board assembly;

FIG. 27 shows the control unit.

FIG. 28 is a constitution block diagram of a controller for an electric outboard motor.

FIG. 29 is a circuit diagram for the electric outboard motor. FIG. 28

FIG. 30 is a constitution block diagram of a controller for the electric outboard motor.

FIG. 31 is a constitution block diagram of a controller for the electric outboard motor.

FIG. 32(a) is a circuit diagram for the accelerator input.

FIG. 32(b) shows accelerator input characteristic.

FIG. 32(c) shows accelerator output characteristic.

FIG. 33 shows the speed controller; a plan view in FIG. 33(a) and a side view in FIG. 33(b). FIG. 34

shows an attachment stay; a plan view in FIG. 34(a), and a side view in FIG. 34(b).

FIG. 35 is a constitution block diagram of a controller for the electric outboard motor.

FIG. 36 is a constitution block diagram of a controller for the electric outboard motor.

FIG. 37 is a circuit diagram of a controller for the electric outboard motor.

An electric outboard drive system of this invention will be hereinafter described in reference to the appended drawings.

First, a controller for an electric outboard motor will be described in reference to FIGs. 1 through 7. FIG. 1 is a view of a watercraft on which the electric outboard motor is mounted. FIG. 2 is a view of the control unit. FIG. 3 is a view of an electric motor drive unit. FIG. 4 is a cross-sectional view of the layout of the printed circuit board of the electric motor drive unit. FIG. 5 is a cross-sectional view taken along the line V-V in FIG. 4. FIG. 6

is a cross-sectional view taken along the line VI-VI in FIG. 4. FIG. 7 is a left side view of the drawing of FIG. 4.

An attachment bracket (3) is secured by tightening with a clamp (4) to the rear part of a hull (2) of a small watercraft (1). A support casing or cylinder (5) is supported with the attachment bracket (3). An electric motor drive unit (6) of the electric outboard motor is disposed at the lower part of the support cylinder (5). A control unit (7) for controlling the electric motor drive unit (6) is disposed at the upper part of the support cylinder (5). The electric motor drive unit (6) and the control unit (7) are interconnected with a wire (20). The electric motor drive unit (6) is operated by operating an operation handle (8). The wire (20) is routed through the inside of the support cylinder (5).

The control unit (7) has a lower case (10) and an upper case (11) as shown in FIG. 2. A control assembly (A) is disposed in the space formed between the lower case (10) and the upper case (11). An electric component (13) for controlling the electric motor drive unit (6) is attached to the printed circuit board (12) of the control assembly.

The electric motor drive unit (6) has a rear bracket (30) on the front side of which is attached an electric motor (31) on the front side of which is attached a cover (32). A propeller (33) is disposed behind the rear bracket (30).

As shown in FIG. 3, the electric motor (31) has a stator (34) and an armature (35). A commutator (37) is mounted on the electric motor drive shaft (36). A brush (38) is disposed in contact with the commutator (37). The electric motor drive shaft (36) is passed through and rotatably supported with the boss portion (30a) of the rear bracket (30). The electric motor drive shaft (36) is connected through a gear (39) to a propeller shaft (40). The gear (39) is covered with a gear cover (41) secured to the inside of the rear bracket (30) by means of a screw bolt (42). The gear cover (41) is farther covered with a cap (43) attached to the rear bracket (30). The propeller shaft (40) is rotatably supported through a bearing (44) with the gear cover (41). A propeller (33) is attached to the end of the propeller shaft (40).

As shown in FIGs. 4 and 5, a brush assembly (B) is included in the rear bracket (30) of the electric motor drive unit (6). A brush holder (50) is secured to the rear bracket (30) by means of a screw bolt (51). The brush (38) is held on the brush holder (50).

A plain bearing (52) for supporting the electric motor drive shaft (36) is provided in the boss portion (30a) of the rear bracket (30). The rear bracket (30) also includes a control assembly (C). The control assembly (C) comprises a heat sink (53), printed circuit boards (54) and (55) all arranged in that order in the direction of the electric motor drive shaft. A switching element (FET) (56) is attached to the heat sink (53). A leg (56a) of the switching element (FET) (56) is connected to the printed circuit board (54). The printed circuit boards (54, 55) are disposed with a certain intervening distance, each provided with an electric component (13).

In this embodiment, of the electric components (13) for controlling the electric motor drive unit (6), those generating a large amount of heat such as the switching element (FET) (56) is disposed within the electric motor drive unit (6) and others generating a small amount of heat such as recirculation diodes, relays, and smoothing condensers are separately disposed within the control unit (7). In this way, the electric components generating a large amount of heat are disposed within the underwater electric motor drive unit (6) and other electric components generating a small amount of heat are separately disposed within the control unit (7) so that the electric components generating a large amount of heat are securely cooled and the controller is made compact as a whole.

Next, the controller for the electric outboard motor will be described in reference to FIGs. 1 through 9. FIGs. 1 through 7 are those described above. FIG. 8 is an enlarged view of the control assembly (C). FIGs. 9(a) and 9(b) are plan views of the printed circuit boards (54) and (55).

The rear bracket (30) includes the control assembly (C) and is disposed within the electric motor drive unit (6). The printed circuit boards (54) and (55) are disposed to oppose each other through conductive spacers (60) tightened and secured with spacer attachment bolts (61). The conductive spacers (60) are made of a metal such as copper or brass so that electric current may be applied to the electric components (13) disposed on the printed circuit boards (54) and (55) through the conductive spacers (60).

In this way, in order to dispose the printed circuit boards (54) and (55) in a narrow space within the rear bracket (30) of the electric motor drive unit (6), a two-height-level structure is employed. The conductive spacers (60) serve to maintain the distance (L1) between the two printed circuit boards (54) and (55) constant and make it possible to apply electric current to the electric components (13) disposed on the printed circuit boards (54) and (55). Therefore, a plural number of printed circuit boards (54) and (55) may be disposed within the small space in the electric motor drive unit (6). Thus, ease of assembly is improved and wiring length is reduced by the employment of the spacers (60).

Next, another controller for the electric outboard motor will be described in reference to FIGs. 1 through 7 and 10 through 13. FIGs. 1 through 7 are those already described. FIG. 10 is an enlarged view of the control assembly (C). FIG. 11 is a plan views of the printed circuit board (54). FIG. 12 is a plan views of the printed circuit board(55). FIG. 13 is a cross-sectional view taken along the line XIII-XIII in Fig. 12.

The rear bracket (30) includes the control assembly (C) and is disposed within the electric motor drive unit (6). The printed circuit boards (54) and (55) are disposed to oppose each other through conductive spacers (60) in a two-height-level structure so that the printed circuit boards may be disposed in a narrow space.

One printed circuit board (54) is formed with a circuit pattern (65) with a copper bar as shown in FIG. 11. Part (65a) of the circuit pattern (65) is bent in an L-shape to be upright on the printed circuit board (54). The other printed circuit board (55) is formed with a circuit pattern (66) with a copper bar as shown in FIGs. 12 and 13. An end portion (66a) of the circuit pattern (66) is formed with a connection hole (55a) through the printed circuit board (55). The end of the circuit pattern (65) bent in the L-shape to be upright is passed through the connection hole (55a), and connected electrically to the end (66a) of the circuit pattern (66) of the other printed circuit board (55) by soldering (67).

In this way, two printed circuit boards (54) and (55) are disposed in the narrow space within the electric motor drive unit (6) by bending to be upright the end of the circuit pattern (65) of one printed circuit board (54) and electrically connecting the circuit pattern (65) to the circuit pattern (66) of the other printed circuit board (55). Thus, ease of assembly is improved and wiring length is reduced.

Next, a further controller for the electric outboard motor will be described in reference to FIGs. 1 through 7 and 14. FIGs. 1 through 7 are those already described. FIG. 14 is an enlarged view of the control assembly (C).

The rear bracket (30) includes the control assembly (C) and is disposed within the electric motor drive unit (6). Printed circuit boards (54) and (55), and a heat sink (53) of the control assembly (C) are provided. On the heat sink (53) are mounted switching elements (FET) (56) as the electric components generating a large amount of heat by means of bolts (68). The electric components generating a large amount of heat are provided with spacers (69) through which the printed circuit board (54) is attached. The spacers (69) are made of an insulation material such as PVC resin.

In this way, vibration to the switching elements (FET) (56) as electric components generating a large amount of heat is reduced as they are supported with the spacers (69) as a result of disposing the heat sink (53) on which electric components generating a large amount of heat are maintained and the printed circuit board (54) within the electric motor drive unit (6) and attaching the electric components generating a large amount of heat to the printed circuit board (54) through spacers (69). Furthermore, the distance between the printed circuit board (54) and the heat sink (53) is kept constant. In comparison to the conventional arrangement, the electric motor drive unit is compact while using the same components and without changing the diameter of the electric motor drive unit. Manufacturing cost is reduced and underwater resistance is reduced.

Next, still another controller for the electric outboard motor will be described in reference to FIGs. 1 through 7 and 15 through 19. FIGs. 1 through 7 are those already described. FIG. 15 is an enlarged view of the control assembly (C). FIG. 16 is a plan view of the wiring surface of the printed circuit board (54). FIG. 17 is a

plan view of the wiring surface of the printed circuit board (55). FIG. 18 is a plan view of the solder surface of the printed circuit board (54). FIG. 19 is a plan view of the solder surface of the printed circuit board (55).

The rear bracket (30) includes the control assembly (C) and is disposed within the electric motor drive unit (6). Printed circuit boards (54) and (55) are disposed in the control assembly (C). Power elements, or four switching elements (FET) (56) are disposed on the printed circuit board (54) circularly around the electric motor drive shaft (36). The legs (56a) of the switching elements (FET) (56) are directed in the same direction of the printed circuit board and soldered. The switching elements (FET) (56) are mounted on the solder surface of the printed circuit board (54). The printed circuit boards (54) and (55) are disposed at a specified distance from each other. The circuit patterns (65) and (66) of the printed circuit boards (54) and (55) are connected by soldering (70) at four locations through wires or copper columns. Terminals (71) previously crimped to wires are connected to the printed circuit board (55) at two locations by tightening with screws (72). A wire (73) is directly soldered (74) to printed circuit board (55) on which a drive IC (75) is mounted.

In this way, many power elements may be disposed in a small space around the electric motor drive shaft (36) so as to surround the electric motor drive shaft (36) and the legs (56a) of the switching elements (FET) (56) may be directed in the same direction, and therefore, routing of the circuit pattern (65) on the printed circuit boards (54) is made in a simple and efficient way and space is saved.

Next, a still further controller for the electric outboard motor will be described in reference to FIGs. 1 through 9. FIGs. 1 through 9 are those already described.

The rear bracket (30) includes the control assembly (C) and is disposed within the electric motor drive unit (6). Printed circuit boards (54) and (55) are disposed in the control assembly (C). The heat sink (53) of the control assembly (C) is installed from the direction of the electric motor drive shaft and secured to the cylindrical surface in the rear bracket (30) by means of bolts (68).

In this way, the heat sink (53) is installed from the direction of the electric motor drive shaft into the electric motor drive unit (6) and secured to the cylindrical surface. Therefore, a single electric component generating a large amount of heat may be attached to the heat sink (53) and then secured to the cylindrical surface. Therefore, ease of assembly is improved and sufficient heat dissipation route is secured.

Next, another controller for the electric outboard motor will be described in reference to FIGs. 1 through 7 and 20 through 22. FIGs. 1 through 7 are those already described. FIG. 20 is a rough view of a wire construction. FIG. 21 is a view seen from the direction (E) in FIG. 20. FIG. 22 is a view of a grommet.

The wire (20) interconnecting the electric motor drive unit (6) and the control unit (7) is bound with a

grommet (80) and a plastic ring (81), and passed through the support cylinder (5). One end (20a) of the wire (20) is connected to the inside of the control unit (7) while the other end (20b) is connected to the inside of the electric motor drive unit (6).

The part of the wire (20) connected to the brush (38) of the brush assembly (B) located inside the electric motor drive unit (6) is provided with a naked crimp terminal (82), a wire (83), an insulation tube (84), a crimp sleeve (85), and a heat shrink tube (86) for increasing flexibility. By the way, the part of the wire disposed within the control unit (7) may be made with a greater flexibility.

In this way, the flexibility of the wire (20) is changed appropriately from its part to part, namely the part of the wire (20) disposed within the electric motor drive unit (6) or within the control unit (7) is made with a greater flexibility. Therefore, wiring is made at a relatively low cost while securing ease of assembly in a narrow space.

As described above, with an embodiment of the invention, the electric components generating a large amount of heat are disposed within the underwater electric motor drive unit while other electric components generating a small amount of heat are disposed in the control unit so that the unit is made compact while securing cooling performance for the electric components generating a large amount of heat.

With another embodiment of the invention, distances among plural number of printed circuit boards are held constant by means of spacers, electric current may be applied to the plural number of printed circuit boards, and the plural number of printed circuit boards are disposed within a narrow space. As a result, ease of assembly is improved, wiring is reduced, the electric motor drive unit is made compact without changing its diameter, compact, at a low cost, and with a reduced underwater resistance.

With a further embodiment of the invention two printed circuit boards are disposed within the narrow space in the electric motor drive unit, with the circuit pattern on one printed circuit board bent to be upright on the board and electrically connected to the circuit pattern on the other board. As a result, ease of assembly is improved, wiring is reduced, the electric motor drive unit is made compact without changing its diameter, compact, at a low cost, and with a reduced underwater resistance.

With still another embodiment of the invention, the heat sink on which the electric components generating a large amount of heat are mounted and the printed circuit board are disposed within the electric motor drive unit, and the printed circuit board is attached to the electric components generating a large amount of heat through the spacers. As a result, vibration to the electric components generating a large amount of heat is reduced, the distance between the printed circuit board and the heat sink is held constant, the electric motor drive unit is made compact without changing its diameter, compact, at a low cost, and with a reduced under-

water resistance.

With a still further embodiment of the invention, many power elements are disposed in a narrow space around the electric motor drive shaft and the legs of the power elements are directed in the same direction. As a result, circuit pattern routing on the board is made efficient and simple to save space. The unit is made compact without changing its diameter, compact, at a low cost, and with a reduced underwater resistance.

With another embodiment of the invention, the heat sink is installed from the direction of the electric motor drive shaft and secured to the cylindrical surface. As a result, the single electric component generating a large amount of heat is attached to the heat sink and then the heat sink may be attached, and therefore, ease of assembly is improved and heat dissipation route is secured.

With a further embodiment of the invention, the flexibility of the wire is changed appropriately from its part to part, namely the part of the wire disposed within the electric motor drive unit or within the control unit is made with a greater flexibility. Therefore, wiring is made at a relatively low cost while securing ease of assembly in a narrow space.

Other embodiments of this invention will be herein-after described in reference to the appended figures 1 and 2 and 23 to 26.

FIG. 1 shows a watercraft on which an electric outboard motor is mounted. FIG. 2 is a plan view of a control unit. FIG. 23 shows the control unit. FIG. 24 shows a printed circuit board assembly. FIG. 25 shows a large current printed circuit board.

An attachment bracket (3) is secured by tightening with a clamp (4) to the rear part of a hull (2) of a small watercraft (1). A support cylinder (5) is supported with the attachment bracket (3). An electric motor drive unit (6) of the electric outboard motor is disposed at the lower part of the support cylinder (5). A control unit (7) for controlling the electric motor drive unit (6) is disposed at the upper part of the support cylinder (5). The electric motor drive unit (6) and the control unit (7) are interconnected with a wire (20). The electric motor drive unit (6) is operated by operating an operation handle (8). The wire (20) is routed through the inside of the support cylinder (5).

The electric motor drive unit (6) has a rear bracket (30) on the front side of which is attached an electric motor (31) on the front side of which is attached a cover (32). A propeller (33) is disposed behind the rear bracket (30).

The control unit (7) has a lower case (10) and an upper case (11). A printed circuit board assembly (A) is disposed in the space formed between the lower case (10) and the upper case (11). A large current printed circuit board (40') through which a large amount of electric current flows and a control printed circuit board (50') on which a CPU (51') is mounted are separately housed in the space formed between the lower case (10) and the upper case (11). A spacer (60') is interposed between

the lower case (10) and the upper case (11). The control printed circuit board (50') is located on the large current printed circuit board (40') and tightened with screws (61, 62). In this way, the large current printed circuit board (40') and the control printed circuit board (50') are located reasonably at different locations, with a short length of the circuit through which a large amount of current flows, and without wire routing to the control printed circuit board (50').

The case of the control unit (7) comprises the lower case (10) and the upper case (11) and they are made of a metal, such as die-cast aluminum. The lower case (10) has integrally formed ribs (10a) to which a large current printed circuit board (40') is attached through a heat sink (80') with screws (99). After placing the heat sink (80) in tight contact with the underside of the large current printed circuit board (40'), a relay (13) and a diode (87) are mounted, secured and soldered. Therefore, the components are assembled in a small size space with good heat dissipation performance.

The heat sink (80') is made of aluminum sheet having a good heat radiation characteristic. The lower case (10) and the upper case (11) constituting the case of the control unit (7) are made of a metal. The heat sink (80') is in direct contact with the ribs (10a) formed integrally with the lower case (10). As a result, heat from the heat sink (80') to which the diode (87) generating a large amount of heat is dissipated to the lower case (10) made of a metal. The heat sink (80') may be attached with simple steps and heat dissipation route is secured. The diode (87) generating a large amount of heat and located on the heat sink (80') has a certain degree of freedom in its layout, and ease of assembling the printed circuit board assembly (A) and ease of attaching the printed circuit board assembly (A) are improved while securing the cooling performance for the diode (87) generating large amount of heat.

A current sensor (85') for detecting current is mounted on the large current printed circuit board (40') provided with a soldering portion (41') and with a terminal (42'). A wire (86') passed through the current sensor (85) is soldered to the soldering portion (41'). A wire (20) from the electric motor drive unit (6) is connected to the terminal (42') by means of a screw. As a result, the preliminary terminal crimping step is eliminated from the assembly process and thus ease of assembly is improved as the wire connection is made in the assembly process.

As shown in FIG. 25, the printed circuit board comprising the large current printed circuit board (40') and the control printed circuit board (50') is located above the mating surfaces of the lower case (10) and the upper case (11). The surface of the large current printed circuit board (40') on which the components are mounted faces downward. The heat sink (80') on which an electric component (70) generating a large amount of heat is mounted is brought into tight contact with the underside of the large current printed circuit board (40'). The heat sink (80') is tightened with a screw (88) of the

diode (87) for instance, and the electric component (13) is mounted.

As described above, since the heat sink (80') in the assembled state is located above the diode (87) which generates a large amount of heat, the heat coming up from the diode (87) is absorbed with the heat sink (80') and efficiently cooled. In the assembled state, the heat sink (80') is disposed above the relay (13) soldered to the large current printed circuit board (40'). The large current printed circuit board (40'), the control printed circuit board (50'), and the heat sink (80') are disposed with a distance from the lower case (10) and above the mating surface (12) between the lower case (10) and the upper case (11). Therefore, even if water enters the inside of the case, the large current printed circuit board (40'), the control printed circuit board (50'), and the heat sink (80') are less likely to be affected. Since the electric components are free from water, the relay (13) is free from short circuit and corrosion.

FIG. 26 shows another embodiment of the printed circuit board assembly, with a side view of the control unit (6) in FIG. 26(a), a bottom view of the printed circuit board assembly in FIG. 26(b), and a cross-sectional view taken along the line VI-VI in FIG. 26(a). A heat sink (90) to which electric components generating a large amount of heat are attached is disposed in the case of the control unit (6). Another heat sink (91) to which electric components generating a large amount of heat are attached is disposed outside the case. Both heat sinks (90) and (91) are interconnected and tightened with screws (92). The external heat sink (91) is inserted through an attachment hole (10b) formed in the lower case (10) and caulking material (93) is injected for sealing.

In this way, as the heat sink (90) to which the electric components are attached is connected to the external heat sink (91), a heat dissipation route is secured. Some degree of freedom in the layout of the electric components generating a large amount of heat on the heat sinks (90) and (91) is provided. Some degree of layout freedom is also provided for other electric components disposed in the case. Ease of assembling the printed circuit board (A) is improved while securing the cooling property of the electric components generating a large amount of heat.

As described above, with an embodiment, the printed circuit board is disposed with a distance from the lower case bottom surface and above the mating surface between the lower and upper cases. Therefore, even if water enters the inside of the case, water does not directly adhere to the electric components on the printed circuit board, and the electric components are prevented from short-circuiting or being corroded. Since the printed circuit board is apart from the lower case bottom surface, the printed circuit board may be easily attached or removed.

With another embodiment, the heat sink is in tight contact with the underside of the printed circuit board and the electric components generating a large amount

of heat are mounted on the heat sink. The heat coming up from the electric components generating a large amount of heat is absorbed with the heat sink and transmitted through the printed circuit board to the case so that the electric components generating a large amount of heat are cooled efficiently.

Further, the control unit case is made of a metal with integrally formed ribs with which the heat sink is in direct contact. Therefore, the heat from the electric components generating a large amount of heat is transmitted to and radiated from the metallic case. The heat sink may be easily attached to secure a heat dissipation route. Some degree of freedom in the layout of the heat generating electric components is provided. Ease of assembling the printed circuit board assembly and ease of attaching the printed circuit board assembly are improved while securing the cooling property of the heat generating electric components.

In addition, the large current printed circuit board through which a large amount of current flows and the control printed circuit board on which the CPU is mounted are separately disposed within the control unit. Therefore, the layout of the electric components is made rational, the circuit through which a large amount of current flows is made short and efficient without wire routing to the control printed circuit board.

With a further embodiment, the heat dissipation route is secured as the heat sink disposed inside the case and on which the electric components generating a large amount of heat are mounted is connected to the heat sink disposed outside the case. The layout of the electric components generating a large amount of heat has some degree of freedom and the ease of preparing the printed circuit board assembly is improved while securing the cooling property of the electric components generating a large amount of heat.

With a still further embodiment, the portion for soldering the wire which passes through the current sensor and a terminal for screw-stopping the wire coming from the electric motor are provided on the large current printed circuit board. Therefore, the preliminary terminal crimping work is made unnecessary in the assembly process and ease of assembly is improved as the wire is connected in the assembly process.

A controller for the electric outboard motor will be hereinafter described in reference to the appended figures 1 and 2 and 27 to 37.

FIG. 1 shows an electric outboard motor which is mounted on a watercraft. FIG. 2 is a plan view of a control unit. FIG. 27 shows the control unit.

An attachment bracket (3) is tightened and secured with a clamp (4) to the rear part of a hull (2) of a small watercraft (1). A support cylinder (5) is supported with the attachment bracket (3). An electric motor drive unit (6) is disposed at the lower part of the support cylinder (5). A control unit (7) is disposed at the upper part of the support cylinder (5). The electric motor drive unit (6) is connected through a wire (20) to the control unit (7) so that the electric motor drive unit (6) is operated by han-

dling an accelerator on an operation handle (8). The wire (20) is routed inside the support cylinder (5).

The electric motor drive unit (6) has a rear bracket (30). An electric motor (31) is attached to the front of the rear bracket (30). A cover (32) is attached to the front of the electric motor (31). A propeller (33) is disposed behind the rear bracket (30).

The control unit (7) has a lower case (10) and an upper case (11) to accommodate a printed circuit board (A). The internal space between the lower case (10) and the upper case (11) accommodates a large current printed circuit board (40) and a control printed circuit board (50) having a CPU (51) at different locations. The control printed circuit board (50) is secured with screws (61, 62) on the large current printed circuit board (40) with a spacer (60) interposed between the two boards. In this way, the large current printed circuit board (40) through which a large current flows and the control printed circuit board (51) having a CPU are disposed separately. The electric components are disposed rationally. The circuit through which a large current flows is formed short and efficiently without the need for wire routing to the control printed circuit board.

The case of the control unit (7) consists of the lower case (10) and the upper case (11) both made of a metal such as die-cast aluminum. A heat sink (80) is secured with screws (99) to ribs (10a) formed integrally with the lower case (10). A diode (87) which is one of the electric components (13) and has a large heat generating characteristic is attached to the heat sink (80). Because of such a construction in which the heat sink (80) is in direct contact with the ribs (10a) formed integrally with the lower case (10), heat from the heat sink (80) is dissipated to the lower case (10). The heat sink (80) is attached with a simple procedure and heat dissipation route is secured. The diode (87) has some degree of freedom in its layout. Therefore, ease of assembling and attaching the printed circuit board (A) is improved while securing the cooling performance of the diode (87).

Since the heat sink (80) is placed in tight contact with the side, on which components are located, of the large current printed circuit board (40), and then the electric components (13) are soldered, the arrangement is made with a small size and good heat dissipation characteristic.

A current sensor (85) for detecting current is mounted on the printed circuit board (40). The printed circuit board (40) is provided with a soldering portion (41) and terminal (42). A wire (86) which passes through the current sensor (85) is soldered to the soldering portion (41). A wire (20) from the electric motor drive unit (6) is connected to the terminal (42). Since the printed circuit board (40) is provided with a portion for soldering the wire (86) and with the terminal (42) for securing the wire (20) with a screw, a terminal crimping process is unnecessary in the assembling process. Since the wire is connected during the assembling process, assembling efficiency is improved.

The circuit board consisting of the large current

printed circuit board (40) and the control printed circuit board (50) is disposed above the mating surface (L2) of the lower case (10) and the upper case (11). The side of the board (40) on which components are located faces downward. The heat sink (80) to which the diode (87) is attached is brought into tight contact with the board (40) and secured for instance with the screws (99) for the diode (87), and the electric components (13) are mounted.

As described above, because the heat sink (80) in the assembled state is located above the diode (87) generating a large amount of heat, the heat generated with the diode (87) rises up and absorbed with the heat sink (80) so that the diode (87) is cooled efficiently. Furthermore, the heat sink (80) is located above the electric components (13) in the state of being mounted on the large current printed circuit board (40). The large current printed circuit board (40), the control printed circuit board (50), and the heat sink (80) are located above the mating surface (L2) of the lower case (10) and the upper case (11). Therefore, even if water enters the inside of the case, the large current printed circuit board (40), the control printed circuit board (50) are less likely to be affected. That is to say, water is less likely to adhere to the electric components (13), so they are prevented from short-circuiting or corrosion.

First, the embodiment of the invention of claim 1 will be described in reference to FIGs. 28 and 29. FIG. 28 is a constitution block diagram of a controller for an electric outboard motor. FIG. 29 is a circuit diagram for the electric outboard motor.

The controller for the electric outboard motor as shown in FIG. 28 is provided with;

electric motor current detection means (101) for detecting the current to the electric motor of the electric outboard motor when the current is not less than a specified value,

electric motor stopping means (102) for stopping the electric motor (31) when the electric motor is in an overloaded state with the current being equal to or greater than the specified value, and

electric motor control means (103) which releases the stop of the electric motor (31) caused by the overcurrent to the electric motor (31) by setting an accelerator to the neutral position and which, when the accelerator is operated to accelerate, causes the electric motor (31) to drive for a specified period of time and then stop.

The electric motor current detection means (101), the electric motor stopping means (102), the electric motor control means (103), and accelerator state detection means (106) are provided in a CPU (51).

As shown in FIG. 29, an output from a current detection circuit (201) provided in a drive circuit (200) of the electric motor (31) is input through a line (202) to the electric motor current detection means (101). The input voltage is used to determine if the current to the electric

motor (31) is not less than a specified value. When the current is not less than the specified value, an output is sent to the electric motor stopping means (102). When the current to the electric motor is an overcurrent as determined by the output from the electric motor current detection means (101), an output is input through a line (203) to a driver circuit (104) to stop the electric motor (31).

The electric motor control means (103) controls the electric motor stopping means (102) according to the output of an accelerator state detection means (106). That is to say, when the electric motor (31) is stopped due to an overcurrent and the accelerator (105) is returned to the neutral position to release the stop of the electric motor (31), and the accelerator is operated to increase the speed again, the electric motor (31) is operated for a specified period of time and then stopped. Thus, the electric motor (31) of the electric outboard motor and the system including power semiconductors are protected. The overcurrent state mostly occurs when the propeller (33) is tangled with weeds. However, lifting the outboard motor above the water for removing the weeds is very cumbersome for the user. To cope with this problem, it is arranged that only when the accelerator is operated from the overcurrent state to the neutral position, the stop of the electric motor is released, and that when the accelerator is opened again, the electric motor is driven for a specified period of time. Thus, power is applied to the propeller (33) only for a short period of time to unravel the weeds entangled around the propeller (33) so that ease of use by the user is improved.

Next another embodiment of the invention will be described in reference to FIGs. 30 and 29. FIG. 30 is a constitution block diagram of a controller for the electric outboard motor.

The controller for the electric outboard motor comprises as shown in FIG. 30; electric component current detection means (210) for detecting the current, when it is equal to or greater than a specified value, of the electric components; electric motor stopping means (211) for stopping the electric motor when the current of the electric components is equal to or greater than the specified value; and electric motor control means (212) for releasing the stop of the electric motor by closing the accelerator from the overcurrent state to the neutral position, driving the electric motor for a specified period of time when the accelerator is opened again, and then stopping the electric motor.

The electric motor current detection means (210), the electric motor stopping means (211), the electric motor control means (212), and accelerator state detection means (106) are provided in a CPU (51).

The electric motor current detection means (210) detects, as shown in FIG. 29, the current of the electric components of the electric outboard motor according to an input through the line (214) of the circuit (213) on the diode side and an input through the line (216) of the circuit (215) on the heat generating component side.

When an overcurrent state is detected in which the overcurrent to the electric components continues for a specified period of time or longer, an output is sent from the electric motor stopping means (211) through the line (203) to the driver circuit (104) to stop the electric motor (31).

The electric motor control means (212) controls the electric motor stopping means (211) according to the output of an accelerator state detection means (106). That is to say, when the electric motor (31) is stopped due to an overcurrent and the accelerator (105) is returned to the neutral position to release the stop of the electric motor (31), and the accelerator is operated to increase the speed again, the electric motor (31) is operated for a specified period of time and then stopped. Thus, the electric motor (31) of the electric outboard motor and the system including power semiconductors are protected. The overcurrent state mostly occurs when the propeller (33) is tangled with weeds. However, lifting the outboard motor above the water for removing the weeds is very cumbersome for the user. To cope with this problem, it is arranged that only when the accelerator is operated from the overcurrent state to the neutral position, the stop of the electric motor is released, and that when the accelerator is opened again, the electric motor is driven for a specified period of time. Thus, power is applied to the propeller (33) only for a short period of time to unravel the weeds entangled around the propeller (33) so that ease of use by the user is improved.

Next a further embodiment of the invention will be described in reference to FIGs. 1 and 30. The electric motor drive unit (6) of the electric outboard motor includes heat generating electric components (213) such as a power element, temperature detection means (214) for detecting the temperature of the heat generating electric components (213); electric motor stopping means (211) for stopping the electric motor when the detected temperature of the electric components is equal to or greater than the specified value; and electric motor control means (212) for releasing the stop of the electric motor by closing the accelerator from the overheat state to the neutral position, driving the electric motor for a specified period of time when the accelerator is opened again, and then stopping the electric motor. The heat generating electric components (213) such as power elements are mounted on the printed circuit board in the electric motor drive unit (6). The temperature detection means (214) detects the temperature of the heat generating components (213) and sends the detected temperature information to the electric motor control means (212) of the CPU (51). When the detected temperature of the heat generating components (213) is not less than a specified value, the electric motor control means (212) controls the electric motor stopping means (211) to stop and protect the electric motor. The electric motor control means (212) also controls when the temperature detected from the output of the accelerator state detection means (106) is

not less than a specified value or in an overheat state, stop of the electric motor is released by operating the accelerator to the neutral position. When the accelerator is opened again, the electric motor is driven for a specified period of time and stopped. Thus, the stop of the electric motor is released by a simple operation on the accelerator and stopped to return the electric motor to an initial state.

Next the embodiment of the invention will be described in reference to FIGs. 31, 32, and 29. FIG. 31 is a constitution block diagram of a controller for the electric outboard motor. FIG. 32(a) is a circuit diagram for the accelerator input. FIG. 32(b) shows accelerator input characteristic. FIG. 32(c) shows accelerator output characteristic.

The controller for the electric outboard motor as shown in FIG. 31 comprises acceleration input means (220) for obtaining acceleration inputs in proportion to movements of the accelerator in the forward and reverse directions from the neutral position of the accelerator, acceleration output means (221) for obtaining from the acceleration input means (220) acceleration output of a quadratic function characteristic having the neutral position at the origin, and electric motor control means (222) using the acceleration output of the quadratic function characteristic for stopping the electric motor (31) with the accelerator at the neutral position, rotating the electric motor (31) in the normal direction with the accelerator moved in the forward direction, and rotating the electric motor (31) in the reverse direction with the accelerator moved in the reverse direction.

The acceleration input means (220), acceleration output means (221), and electric motor control means (222) are provided in the CPU (51). As shown in FIG. 8(a), an output is issued from the accelerator input circuit (223) when the accelerator (105) is operated. The output is used to obtain an acceleration input of the characteristic shown in FIG. 8(b) through the acceleration input means (220). Acceleration input in proportion to the movement of the accelerator in either forward or reverse direction from the neutral position is obtained by the accelerator operation.

The acceleration output means (221) obtains acceleration output of the quadratic function characteristic with its origin at the neutral position from the acceleration input shown in FIG. 8(c), and outputs electric motor current for the normal and reverse rotations by the accelerator movements in the forward and reverse directions.

In this way, the acceleration input is obtained in proportion to the movement of the accelerator (105) in the forward and reverse directions from the neutral position. From the acceleration input is obtained the acceleration output of the quadratic function characteristic with its origin at the neutral position. The output of the quadratic function characteristic is used to stop the electric motor (31) with the accelerator at the neutral position, to rotate the electric motor (31) in the normal direction with the accelerator moved in the forward direction, and to rotate

the electric motor (31) in the reverse direction with the accelerator moved in the reverse direction. Therefore, feeling of a quadratic characteristic is obtained easily at a low cost, ease of use in low speeds is improved, and man-hour is reduced as adjustment of acceleration characteristic is unnecessary.

Next another embodiment of the invention will be described in reference to FIGs. 33 and 34. FIG. 33 shows the speed controller; a plan view in FIG. 33(a) and a side view in FIG. 33(b). FIG. 34 shows an attachment stay; a plan view in FIG. 34(a), and a side view in FIG. 34(b).

The controller of the electric outboard motor is provided with an attachment stay (230) having a punched hole (230d) and an erected attachment portion (230b). To the attachment portion (230b) is attached a speed control means (240) comprising a potentiometer (241) operated with an operation handle (8) shown in FIG. 27, and a resistor (242). The resistor (242) is attached to the attachment stay (230) with the potentiometer (241) inserted in the punched hole (230d). A wire (243) is passed through the punched hole (230d) of the attachment stay (230) and connected by soldering to the resistor (242).

In this way, by attaching the potentiometer (241) and the resistor (242) of the speed control means (240) to the attachment portion (230b) of the attachment stay (230) and passing the wire (243) through the punched hole (230d) of the attachment stay (230), the wire is connected by soldering to the resistor (242) of the speed control means (240) without being hindered with the attachment stay (230). That is to say, ease of attaching and soldering the wire (243) is improved with a simple structure of the attachment stay even after the attachment of the speed control means (240), and degree of freedom is provided to the process.

Next another embodiment of the invention will be described in reference to FIGs. 35 and 29. FIG. 35 is a constitution block diagram of a controller for the electric outboard motor.

As shown in FIG. 35, the controller for the electric outboard motor is provided with battery voltage detection means (250) for detecting the battery voltage at the time the battery (252) of the electric outboard motor is connected, electric motor start prohibition means (251) for prohibiting the start of the electric motor (31) when the battery voltage is not less than a specified value, and start prohibition release means (253) for releasing the start prohibition of the electric motor (31) by disconnecting the battery (252).

The battery voltage detection means (250), the electric motor start prohibition means (251), and the start prohibition release means (253) are provided in the CPU (51). The battery voltage detection means (250) detects, as shown in FIG. 29, the battery voltage from the input through the line (256) of the circuit (255) connected to the drive circuit (200) of the electric motor (31) when the battery is connected.

In this way, the system is protected against dam-

age, when additional battery (252) is connected in series to increase the output, by detecting the battery voltage of the electric outboard motor when the battery is connected, prohibiting the start of the electric motor when the battery voltage is not less than the specified value, releasing the prohibition of the start of the electric motor (31) by disconnecting the battery (252).

Next the embodiment of the invention of claim 7 will be described in reference to FIGs. 36 and 29. FIG. 36 is a constitution block diagram of a controller for the electric outboard motor.

As shown in FIGs. 29 and 36, the controller for the electric outboard motor is provided with a time constant circuit (261) included in a control power source circuit (260) of the electric outboard motor, voltage detection means (262) for detecting the voltage of the time constant circuit (261), and control means (263) for continuing the operation of the electric outboard motor when the detected voltage of the time constant circuit (261) is not less than a specified voltage and control information is normal.

The voltage detection means (262) and the control means (263) are provided in the CPU (51). When the control power source (Vcc) is interrupted by a certain cause such as rattling of the battery (252) due to vibration during navigation, the voltage of the electrolytic condenser (C1) constituting the time constant circuit (261) is detected. If the detected voltage of the time constant circuit (261) is not less than a specified value and control information is normal, the operation of the electric outboard motor is continued. Otherwise, when the control power source (Vcc) is interrupted by a certain cause such as rattling of the battery (252) due to vibration during navigation, the operation of the electric outboard motor is stopped. In this way, when the control power source (Vcc) is interrupted by a certain cause such as rattling of the battery (252) due to vibration during navigation, the system is reset (264) to perform initialization process. Even if the accelerator is open here, the electric outboard motor is prevented from stopping. The operation of the electric motor (31) is continued only when control information is not destroyed.

Next a further embodiment of the invention will be described in reference to FIGs. 37. FIG. 37 is a circuit diagram of a controller for the electric outboard motor.

The controller for the electric outboard motor is provided with a power source circuit (270) having an electrolytic condenser (C2), a delay circuit (271) for delaying the charging of the electrolytic condenser (C2), a short circuit (272) for stopping electric current to the delay circuit (271) in normal state, and a time constant circuit (273) for closing the short circuit (272) when the electrolytic condenser (C2) is charged sufficiently.

To make the rotation of the electric motor smooth, a large capacity electrolytic condenser (C2) is used as a smoothing condenser which is charged through a diode (D1) and a resistor (R1) when the battery (252) is connected. The delay circuit (271) comprises a diode (D2), and a resistor (R2) and delays the charging of the elec-

trolytic condenser (C2) by charging the electrolytic condenser (C3) of the time constant circuit (273).

The short circuit (272) comprises resistors (R3, R4, R5), condensers (C4, C5), a diode (D3), a thyristor (SR1), and a relay (L1), and in the normal state it prevents electric current from flowing through the delay circuit (271) as the electrolytic condenser (C2) is sufficiently charged, the thyristor (SR1) is closed, the relay (L1) is actuated, and grounded through the resistor (R10).

In this way, a large capacity electrolytic condenser (C2) is used as a smoothing condenser to smooth the rotating operation of the electric motor (31). Therefore, in the normal state, electric current is prevented from flowing to the delay circuit (271) to delay the charging of the electrolytic condenser (C2). When the electrolytic condenser (C2) is charged sufficiently, the short circuit (272) is closed to prevent a closing current from flowing to the electrolytic condenser (C2), to prevent a fire from occurring, and to prevent a user from being startled by the spark occurring when the user connects the battery.

As described above, the electric motor is stopped when the electric motor current is not less than the specified value to protect the system comprising the electric motor of the electric outboard motor, power semiconductors, etc. When the accelerator is operated from the overcurrent state to the neutral position, the stop of the electric motor is released. When the accelerator is opened again, the electric motor is operated only for a specified period of time. The release from the overcurrent state is possible only when the accelerator is set to the neutral position. This improves the ease of use by the user by making it possible to apply power to the propeller for a short period of time to unravel the weed tangled on the propeller.

Further, the electric motor is stopped when the overcurrent state occurs in which the electric component current continues for not less than a specified period of time to protect the system comprising the electric motor of the electric outboard motor, power semiconductors, etc. When the accelerator is operated from the overcurrent state to the neutral position, the stop of the electric motor is released. When the accelerator is opened again, the electric motor is operated only for a specified period of time. The release from the overcurrent state is possible only when the accelerator is set to the neutral position. This improves the ease of use by the user by making it possible to apply power to the propeller for a short period of time to unravel the weed tangled on the propeller.

In addition, the electric motor is stopped when the detected temperature of the heat generating electric components is not less than a specified value to protect the electric motor. When the accelerator is operated from the overheat state to the neutral position, the stop of the electric motor is released. When the accelerator is opened again, the electric motor is operated for a specified period of time and then stopped. Thus, the

electric motor is returned automatically to the initial state with a simple accelerator operation.

With another embodiment, the acceleration output of the quadratic function characteristic with the neutral position at the origin is obtained from the acceleration input which is in proportion to the movement of the accelerator in both forward and reverse directions from the neutral position. The acceleration output of the quadratic function characteristic is used to stop the electric motor with the accelerator at the neutral position, to operate the electric motor in the normal rotating direction with the accelerator operated in the forward direction, and in the reverse rotating direction with the accelerator operated in the reverse direction. Thus, the quadratic characteristic feeling is obtained simply at a low cost, ease of use at very low speeds is improved, and man-hour is reduced as adjustment of the accelerator characteristic is unnecessary.

With a further embodiment, the speed control means is attached to the attachment portion of the attachment bracket, the wire is passed through the punched hole of the attachment stay, the attachment stay does not stand in the way of the soldering connection to the speed control means. That is to say, ease of attaching and soldering the wire is improved with a simple structure of the attachment stay even after the attachment of the speed control means, and degree of freedom is provided to the process.

Further, the battery voltage at the time of the battery connection of the electric outboard motor is detected. When the detected battery voltage is not less than a specified value, start of the electric motor is prohibited. Since the prohibition of the electric motor start is released by disconnecting the battery, the system is protected against damage when additional battery is connected in series to increase output.

Still further, the voltage of the time constant circuit provided in the control power source circuit of the electric outboard motor is detected. The operation of the electric outboard motor is continued only when the detected voltage of the time constant circuit is not less than the specified value and the control information is normal. When the control power source is interrupted, the system is reset to perform initialization process. Here, the problem of undesirable stop of the electric outboard motor when the accelerator is open is eliminated. The operation of the electric motor is continued with the previous operation mode only when control information is not destroyed.

In addition, a large capacity electrolytic condenser is used as a smoothing condenser to smooth the rotating operation of the electric motor. Therefore, in the normal state, electric current is prevented from flowing to the delay circuit to delay the charging of the electrolytic condenser. When the electrolytic condenser is charged sufficiently, the short circuit is closed to prevent a closing current from flowing to the electrolytic condenser, to prevent a fire from occurring, and to prevent a user from being startled by the spark occurring when

the user connects the battery.

Claims

1. An electric outboard drive system for a watercraft having a support casing (5) fastenable on a hull (2), an electric drive unit (6) disposed at the lower part of the support casing (5), and a control unit (7) disposed at the upper part of the support casing (5) for controlling the electric motor drive unit (6), **characterized in that** electric components (13) generating a large amount of heat during operation are disposed within the electric drive unit (6) and electric components (13') generating a comparable smaller amount of heat during operation are disposed in the control unit (7).
2. An electric outboard drive system for a watercraft according to claim 1, **characterized in that** a plural number of printed circuit boards (54, 55) are disposed within the electric motor drive unit (6) with conductive spacers (60) interposed among the printed circuit boards (54, 55) so that electric current is applicable to electric components (13) disposed on the plural number of printed circuit boards (54, 55).
3. An electric outboard drive system for a watercraft according to claim 1 or 2, **characterized in that** a plural number of printed circuit boards (54, 55) are disposed within the electric motor drive unit (6), a circuit pattern (65) on one printed circuit board (54) is bent and erected on the printed circuit board (54) and the circuit pattern (65) is electrically connected to a circuit pattern (66) of another printed circuit board (55).
4. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 3, **characterized in that** a heat sink (53) on which electric components (56) generating a large amount of heat are mounted and a printed circuit board (54) are disposed within the electric motor drive unit (6), and the printed circuit board (54) is attached through a spacer (69) to the electric components (56) generating a large amount of heat.
5. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 4, **characterized in that** a printed circuit board (54) is disposed within the electric motor drive unit (6) and a power element (56) is disposed on the printed circuit board (54) so as to surround the electric motor drive shaft (36).
6. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 5, **characterized in that** a heat sink (53) is disposable within the electric motor drive unit (6) from

the direction of the electric motor drive shaft (36) and secured on the inside cylindrical surface.

7. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 6, **characterized in that** part of a portion, disposed within the electric motor drive unit (6) or within the control unit (7), of a wire (83) interconnecting the electric motor drive unit (6) and the control unit (7) is adapted to have a greater flexibility than the other part.
8. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 7, **characterized in that** a printed circuit board (50') is disposed at a location which is within a space between upper and lower cases (11, 10) of the control unit (7), separated from the bottom of the lower case (10), and above the mating surfaces of the upper and lower cases (11, 10).
9. An electric outboard drive system for a watercraft according to claim 8, **characterized in that** a heat sink (80') is brought in tight contact with the underside surface of the printed circuit board (50') and the electric components (13) generating a large amount of heat are mounted on the heat sink (80').
10. An electric outboard drive system for a watercraft according to claim 8 or 9, **characterized in that** the case of the control unit (7) is made of a metal and formed with integral ribs (10a) to which a heat sink (80') for mounting electric components (13) generating large amount of heat is attached.
11. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 10, **characterized in that** a large current printed circuit board (40') through which a large amount of current flows and a control printed circuit board (50') on which a CPU (51') is mounted are separately disposed within the control unit (7).
12. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 11, **characterized in that** a heat sink (90) for mounting electric components (13) generating large amount of heat is disposed within the control unit case, another heat sink (91) is disposed outside the case, and the internal and external heat sinks (90, 91) are interconnected.
13. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 12, **characterized in that** a large current printed circuit board (40') through which a large amount of current flows is disposed within the control unit (7), a current sensor (85') for detecting electric current is disposed on the large current printed circuit

board (40') and the large current printed circuit board (40') is provided with a portion (41') for soldering a wire (86') coming from the electric motor drive unit (6) through the current sensor (85') and with a terminal (42') to which the wire (86') is connectable.

14. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 13, **characterized in that** the controller is provided with,
electric motor current detection means (101) for detecting the current to the electric motor (31) when the current is not less than a specified value,
electric motor stopping means (102) for stopping the electric motor (31) in an overcurrent state in which the current to the electric motor (31) is not less than a specified value,
electric motor control means (103) for releasing the stop of the electric motor (31) by operating an accelerator (105) from the overloaded state to the neutral state,
driving the electric motor (31) for a specified period of time when the accelerator (105) is opened again, and stopping the electric motor (31).
15. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 14, **characterized in that** the controller is provided with,
electric motor current detection means (210) for detecting the current to electric components of the electric motor (31) when the current is not less than a specified value,
electric motor stopping means (211) for stopping the electric motor (31) in an overloaded state in which the detected current to the electric components is not less than a specified value,
electric motor control means (212) for releasing the stop of the electric motor (31) by operating an accelerator (105) from the overloaded state to the neutral state,
driving the electric motor (31) for a specified period of time when the accelerator (105) is opened again, and for stopping the electric motor (31).
16. An electric outboard drive system for a watercraft according to at least one of the preceding claims 1 to 15, **characterized in that** the controller is provided with,
temperature detection means (214) for detecting the temperature of the electric components (213) of the electric motor (31),
electric motor stopping means (211) for stopping the electric motor (31) when the detected temperature is not less than a specified value,
electric motor control means (212) for releasing the stop of the electric motor (31) by operating an accelerator (105) from the overheated state in

which the temperature is not less than the specified value to the neutral state, driving the electric motor (31) for a specified period to time when the accelerator (105) is opened again, and for stopping the electric motor (31).

17. An electric outboard drive system for a watercraft according to at least one of the preceding claims 14 to 16, **characterized in that** the controller is provided with,

acceleration input means (220) for obtaining acceleration input in proportion to movements of the accelerator (105) from the neutral position to forward and reverse directions,

acceleration output means (221) for obtaining from the acceleration input means (220) acceleration output of quadratic function characteristic with its origin at the neutral position, and

electric motor control means (222) using the acceleration output of the quadratic function characteristic for stopping the electric motor (31) by setting the accelerator (105) to the neutral position, operating the electric motor (31) in the normal rotating direction by forward movement of the accelerator (105), and in the reverse rotating direction by the reverse movement of the accelerator (105).

18. An electric outboard drive system for a watercraft according to at least one of the preceding claims 14 to 17, **characterized in that** the controller is provided with,

an attachment stay (230) with part of it having a punched hole (230d) and a bent and erected attachment stay having an attachment portion (230b),

speed control means (240) operated with the accelerator (105) and attached to the attachment portion (230b), and speed control wire (243) passed through the punched hole (230d) of the attachment stay (230) and connected by soldering to the speed control means (240).

19. An electric outboard drive system for a watercraft according to at least one of the preceding claims 14 to 18, **characterized in that** the controller is provided with,

battery voltage detection means (250) for detecting the voltage of a battery (252) of the electric outboard drive system for a watercraft when it is connected,

electric motor start prohibiting means (251) for prohibiting the start of the electric motor (31) when the battery voltage is not less than a specified value, and

start prohibition releasing means (253) for releasing the stop of the electric motor (31) by disconnecting the battery (252).

20. An electric outboard drive system for a watercraft

according to at least one of the preceding claims 14 to 19, **characterized in that** the controller is provided with,

a time constant circuit (261) provided in a control power source circuit (260) of the electric outboard drive system for a watercraft,

voltage detection means (262) for detecting the voltage of the time constant circuit (261), and

control means (263) for continuing the operation of the electric outboard drive system for a watercraft only when the detected voltage of the time constant circuit is not less than the specified value and control information is normal.

21. An electric outboard drive system for a watercraft according to at least one of the preceding claims 14 to 20, **characterized in that** the controller is provided with,

a power source circuit (270) having an electrolytic condenser (C2) for the electric outboard drive system for a watercraft,

a delay circuit (271) for delaying the charging of the electrolytic condenser (C2),

a short circuit (272) for preventing an electric current from flowing to the delay circuit (271) in normal state, and

a time constant circuit (273) for closing the short circuit (272) when the electrolytic condenser (C2) is sufficiently charged.

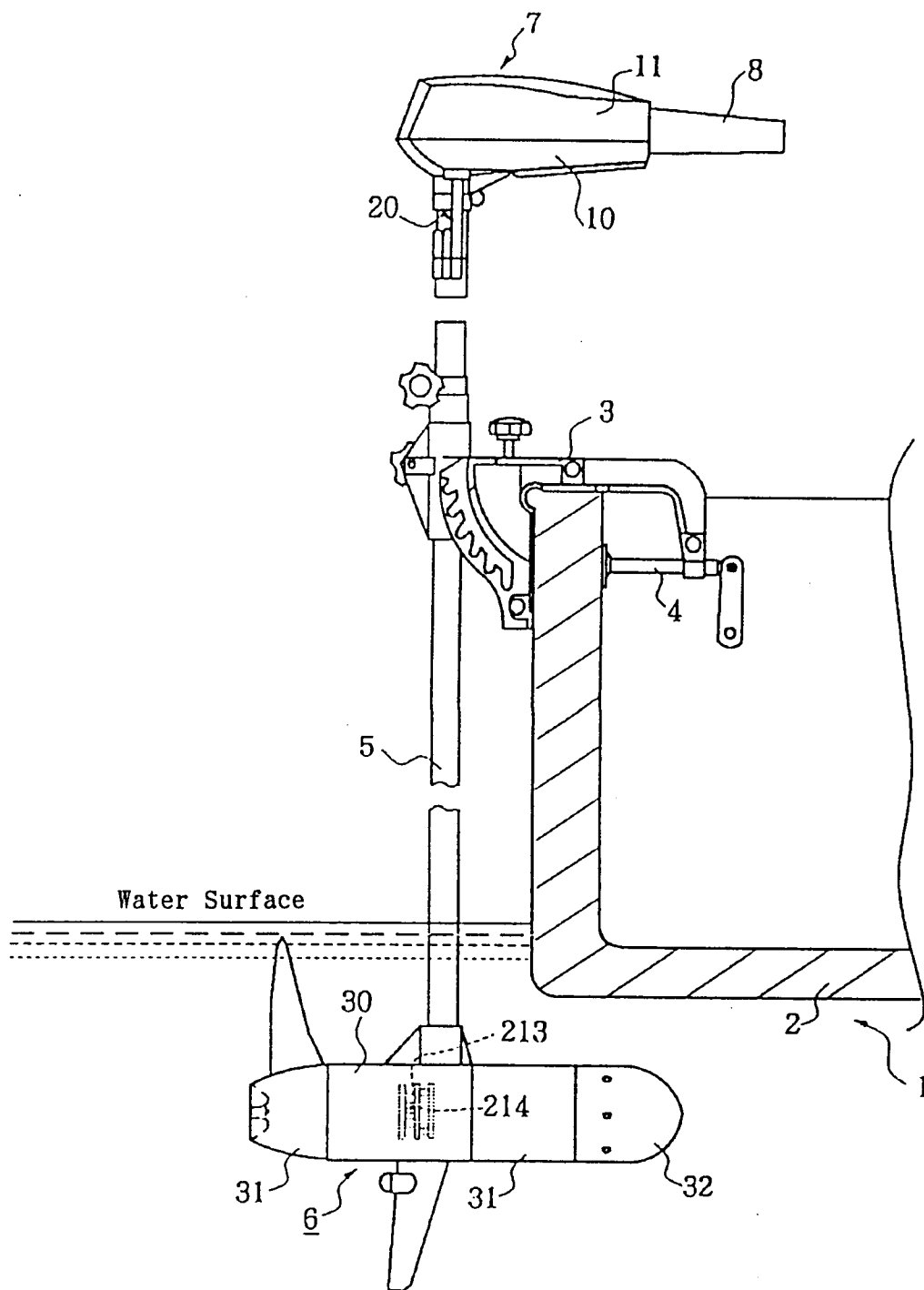


FIGURE 1

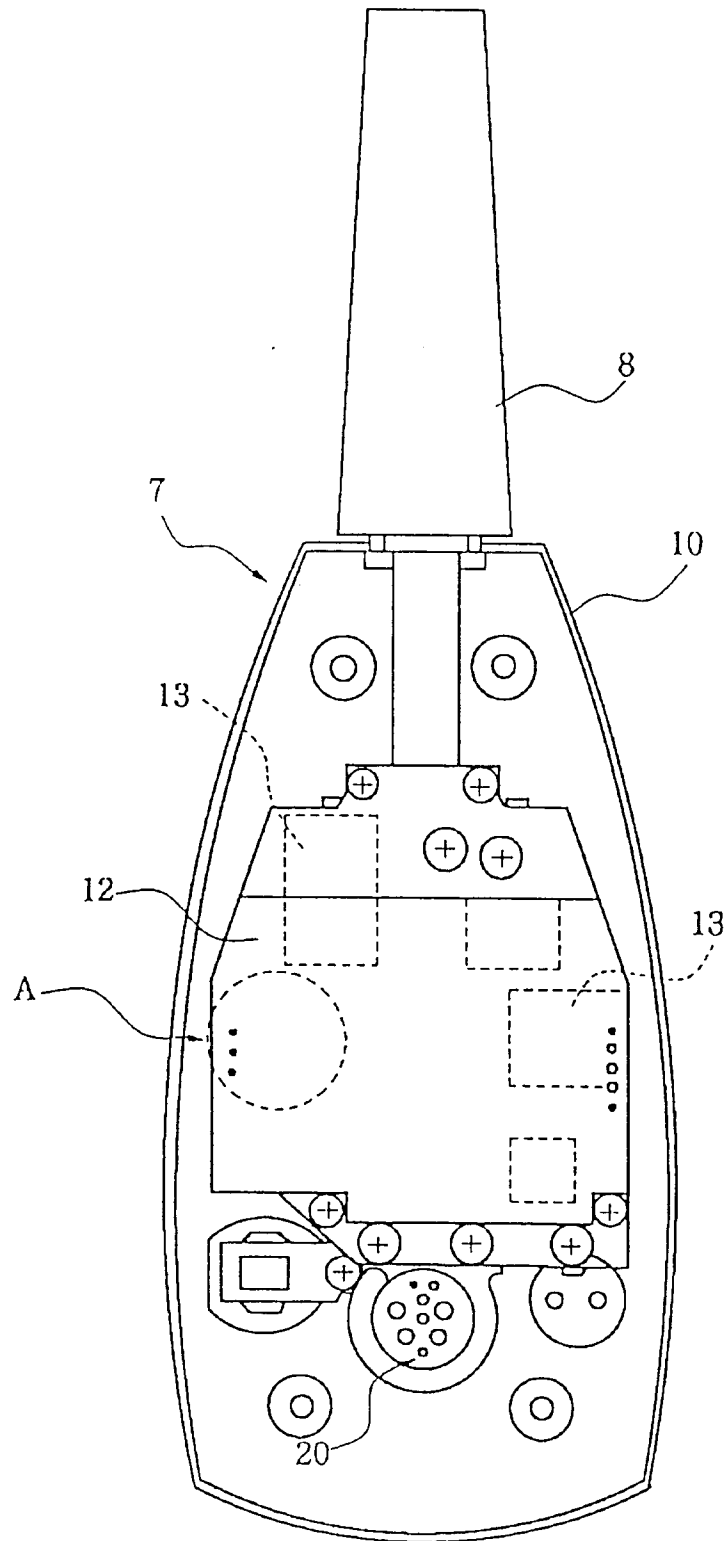
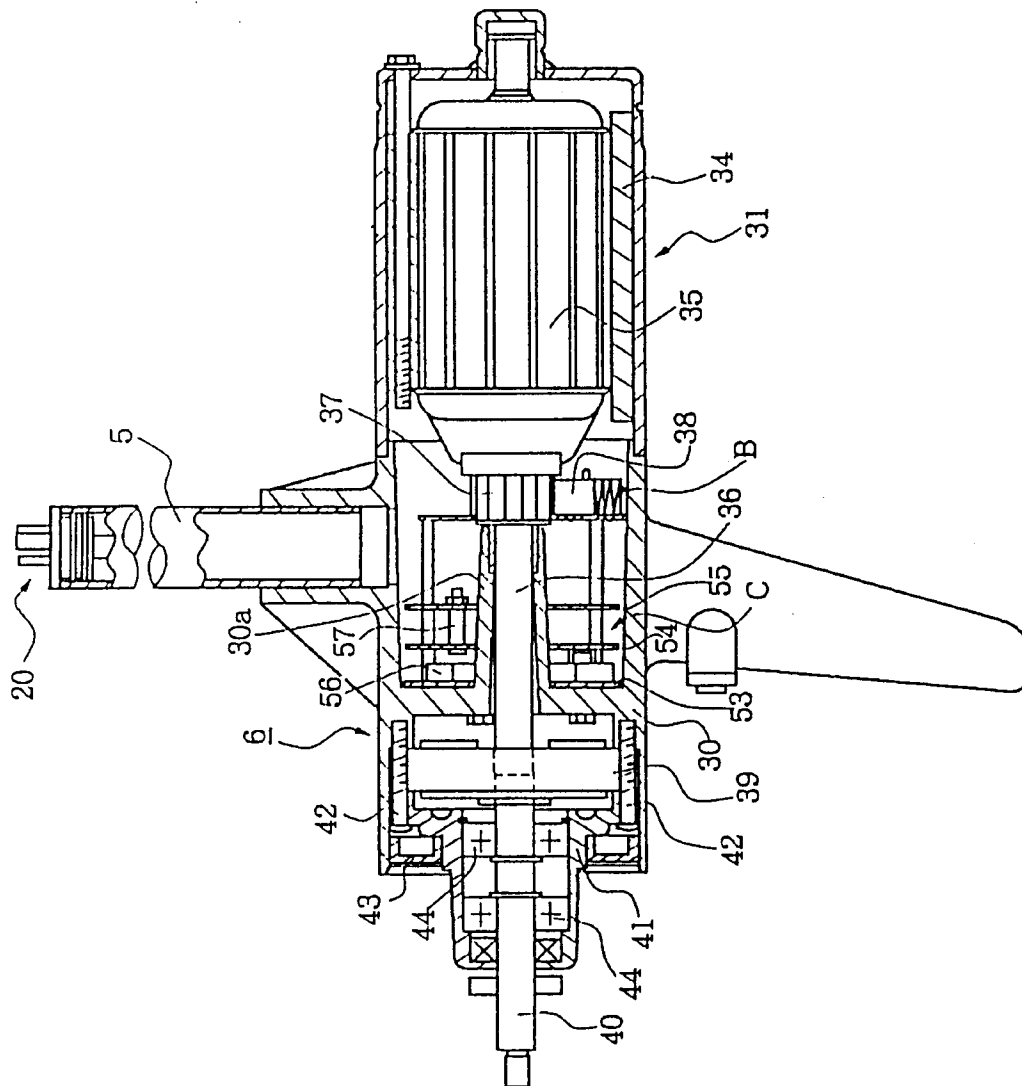


FIGURE 2



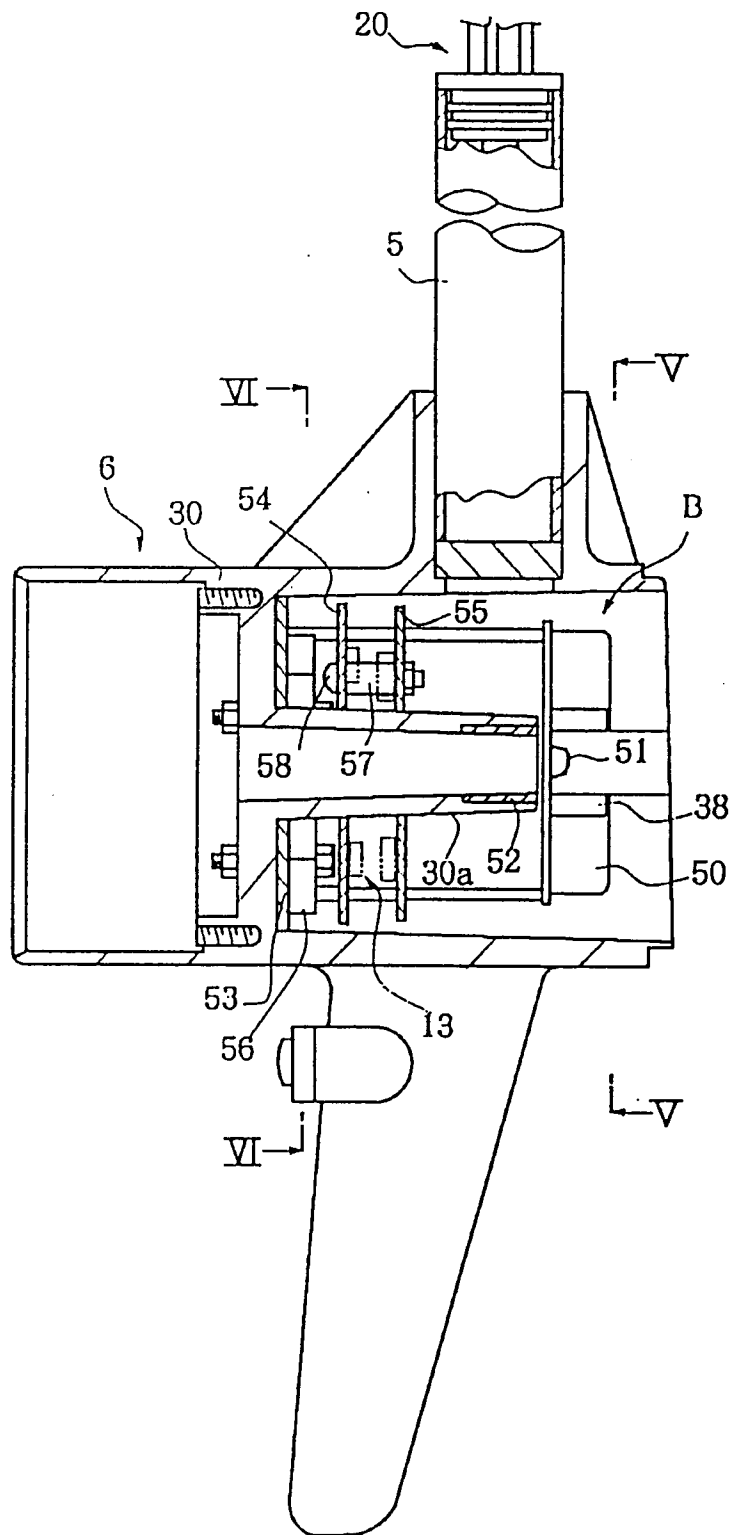


FIGURE 4

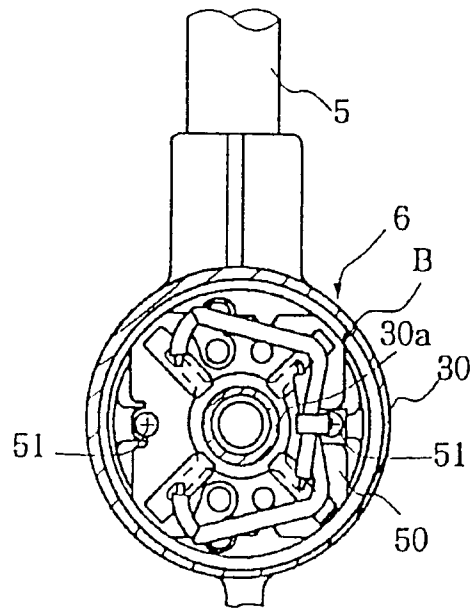


FIGURE 5

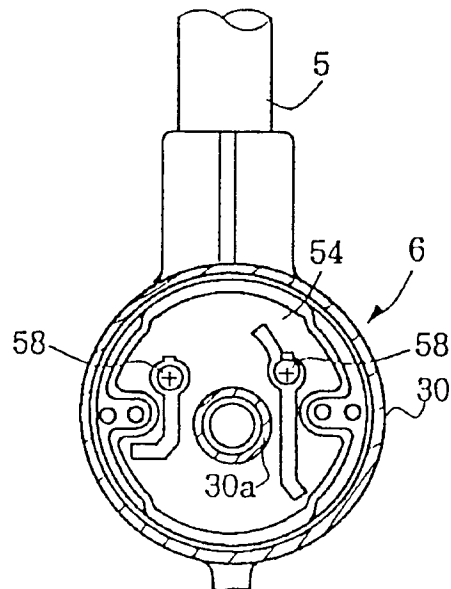


FIGURE 6

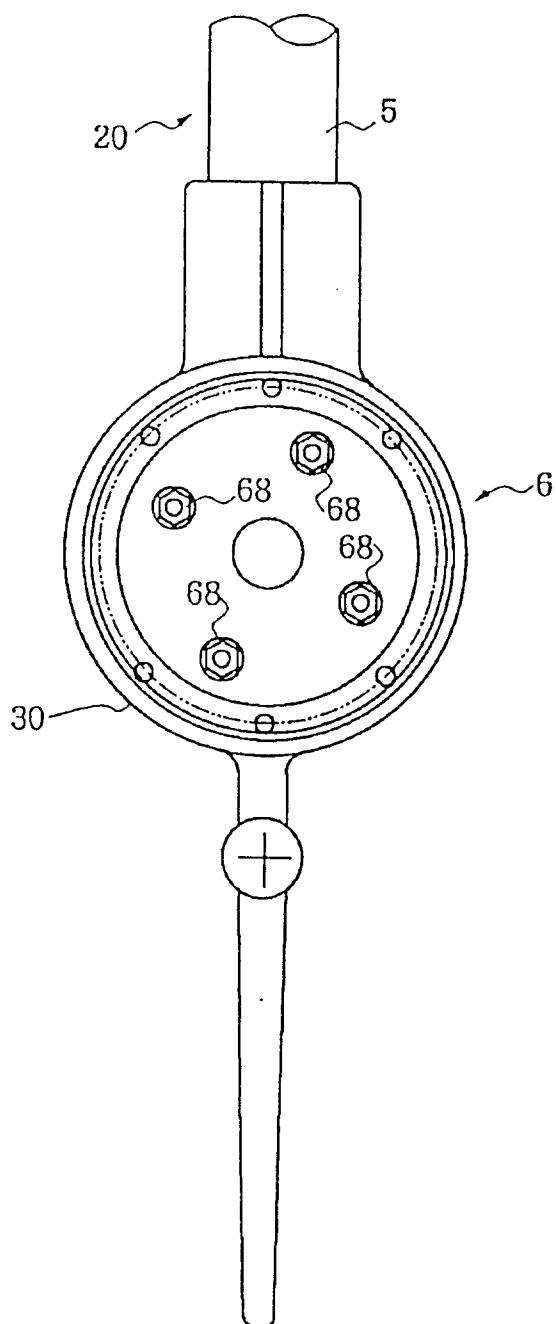


FIGURE 7

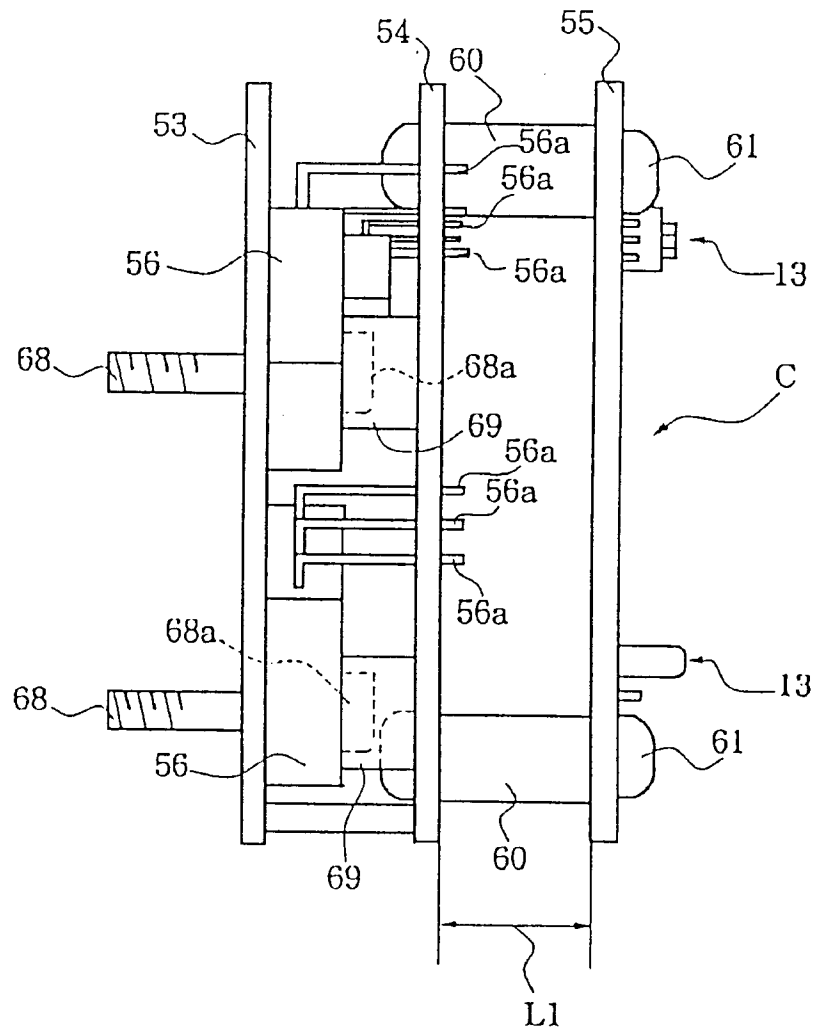
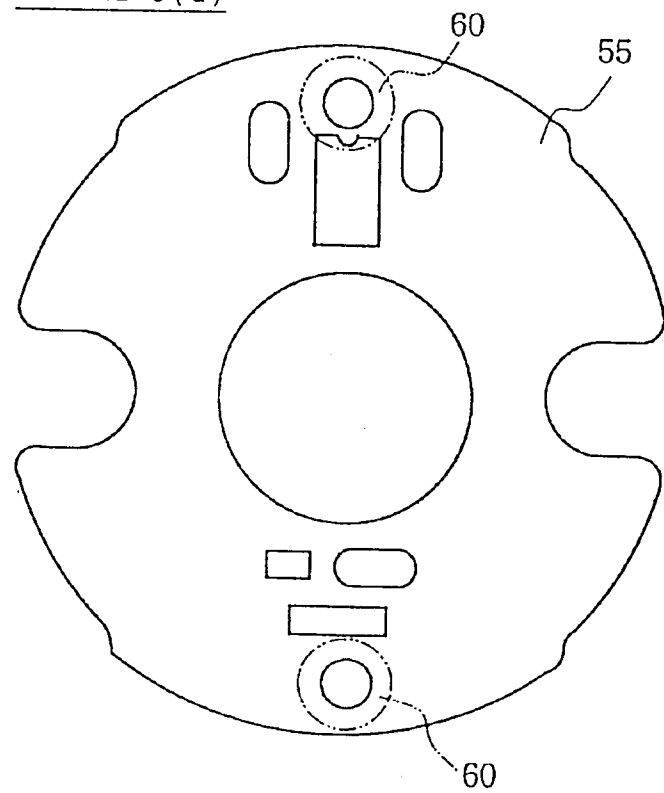
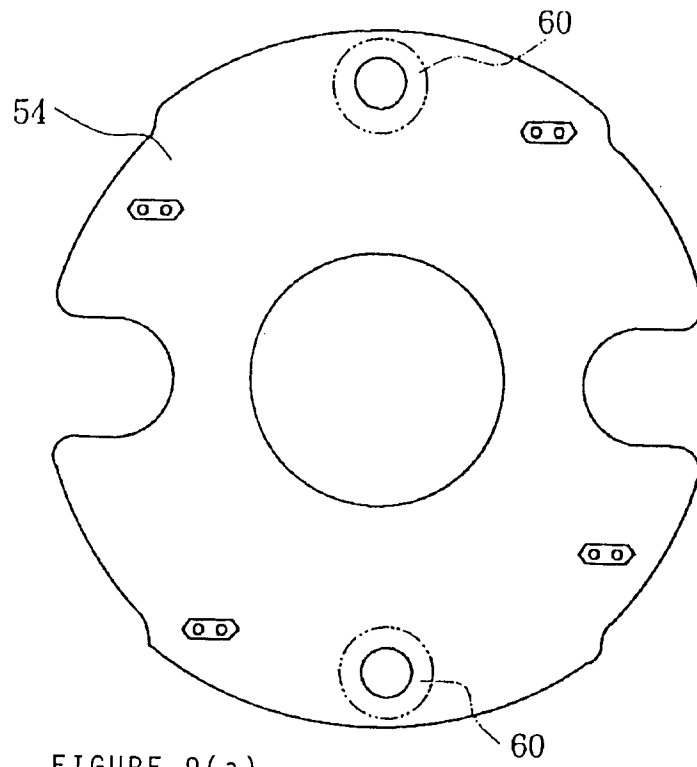


FIGURE 8



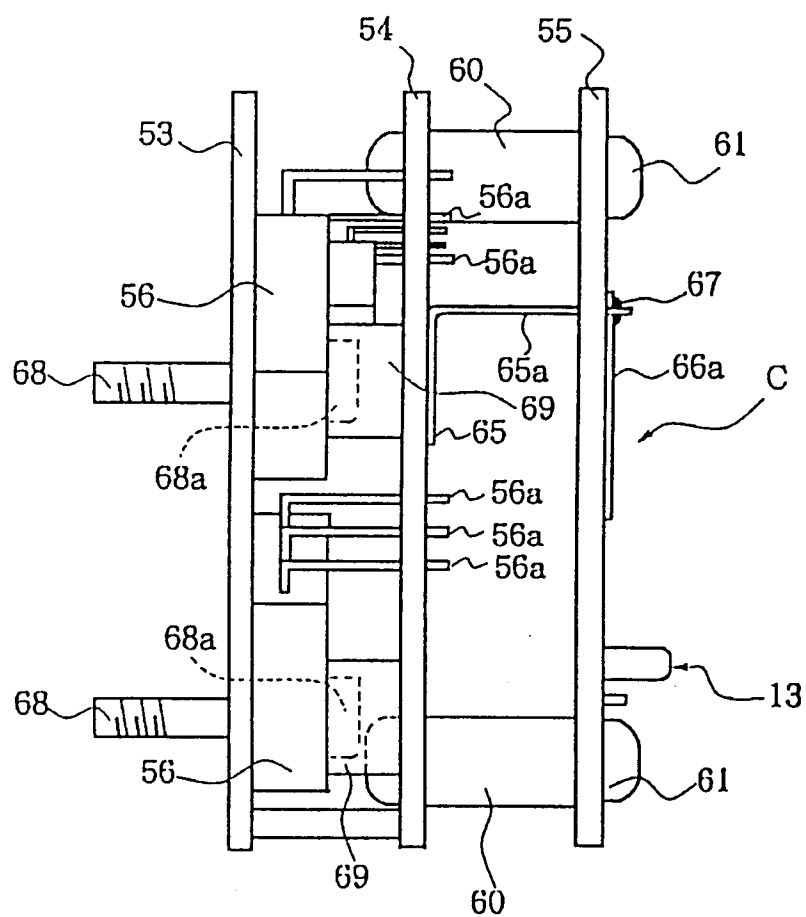


FIGURE 10

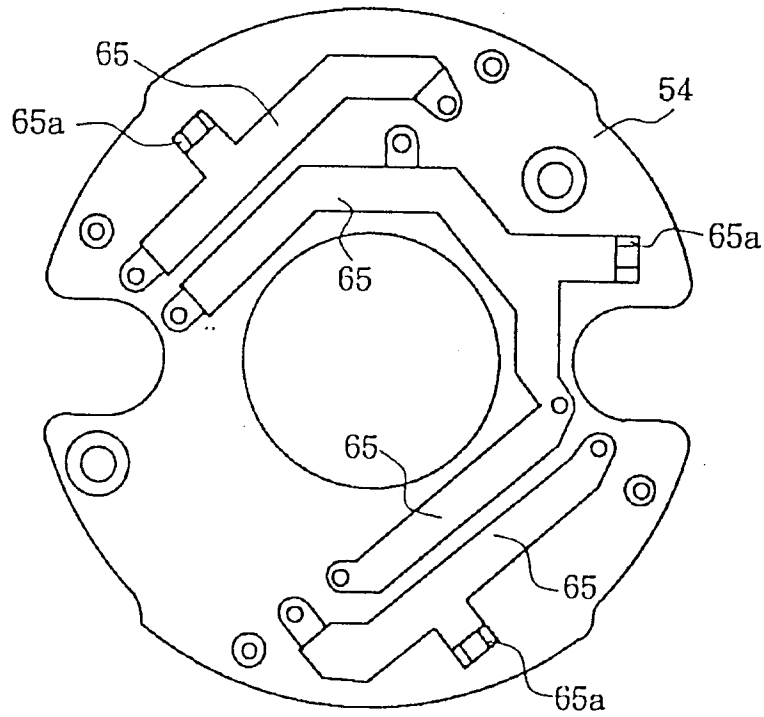


FIGURE 11

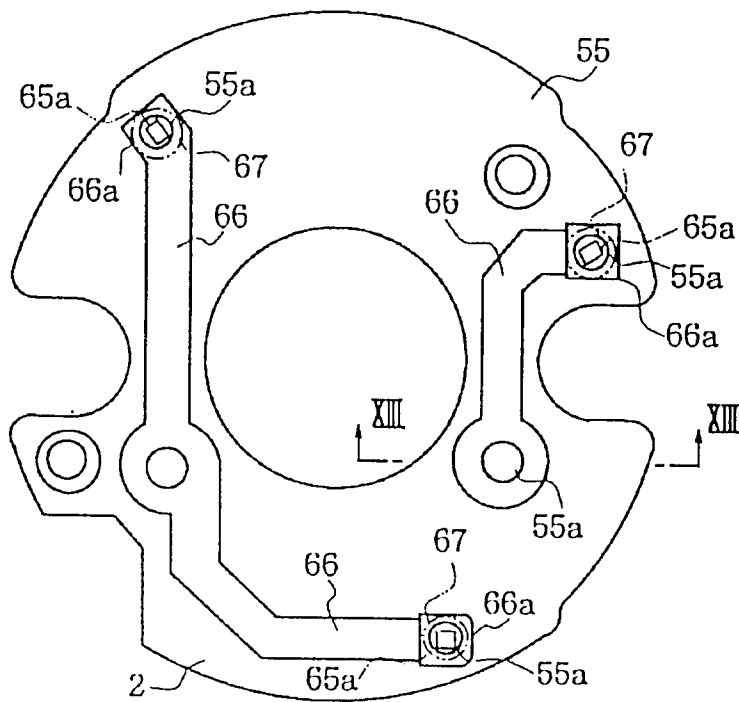


FIGURE 12

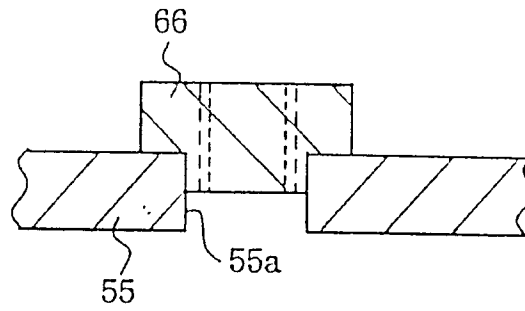


FIGURE 13

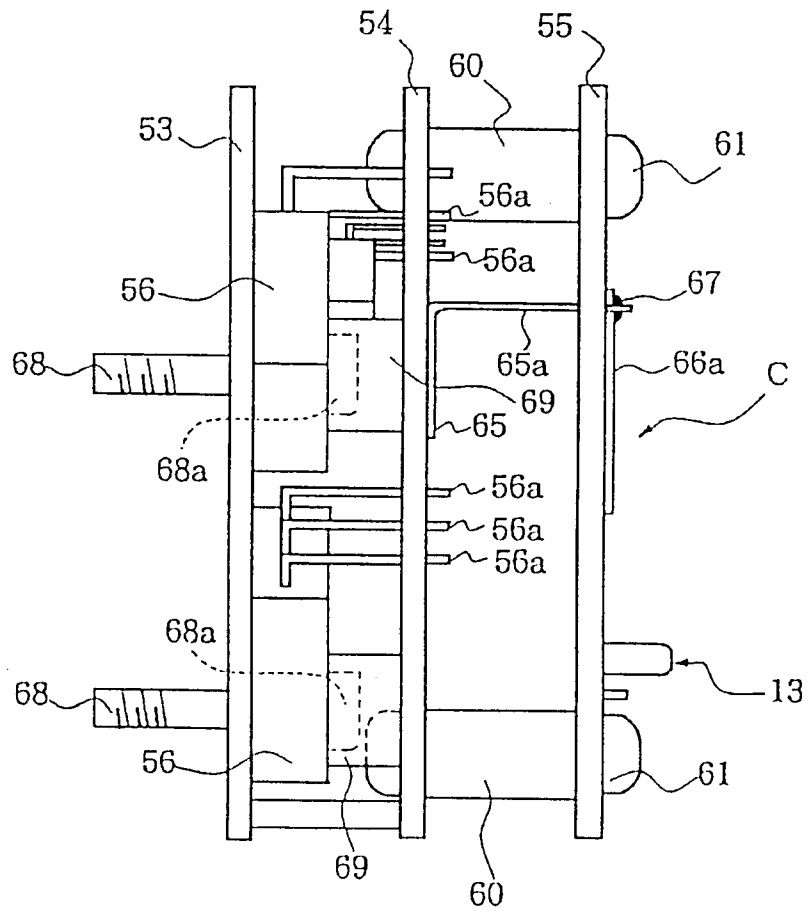


FIGURE 14

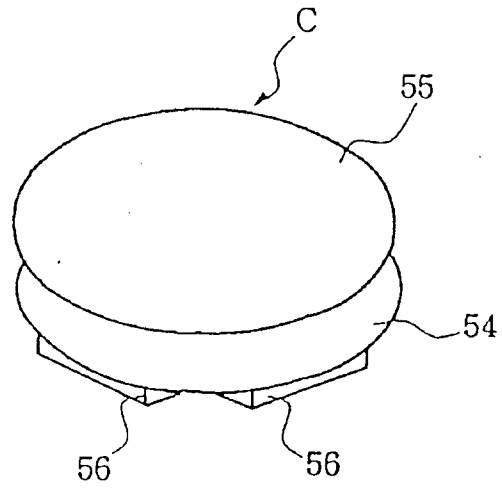


FIGURE 15

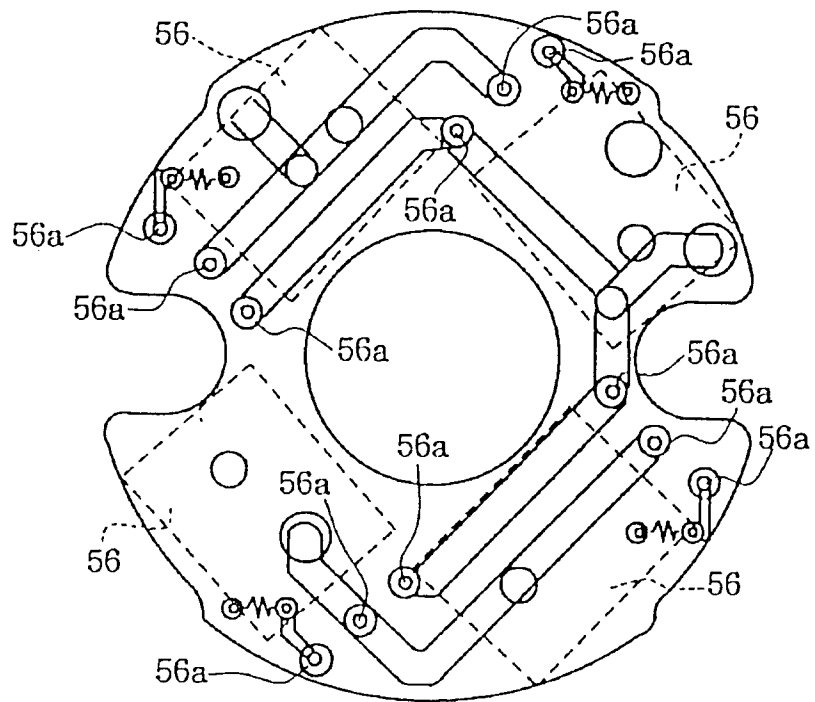


FIGURE 16

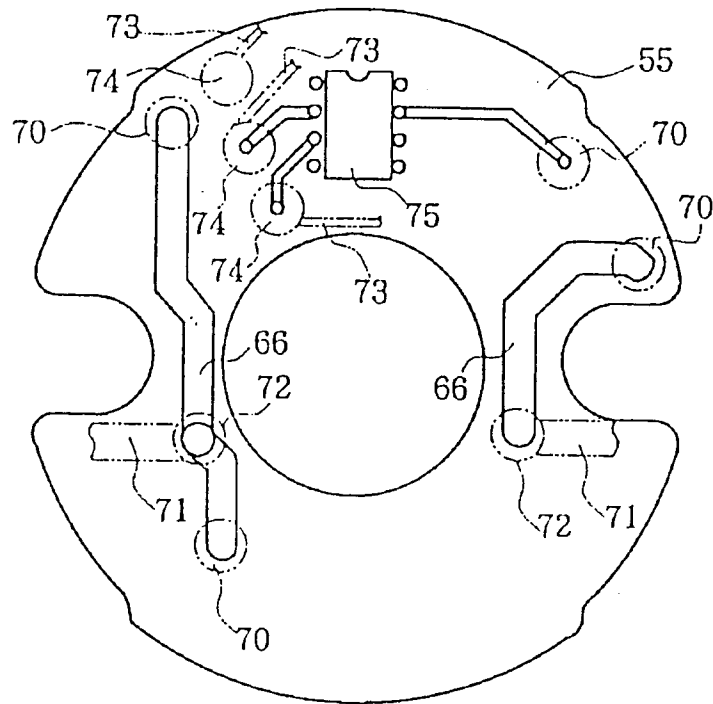


FIGURE 17

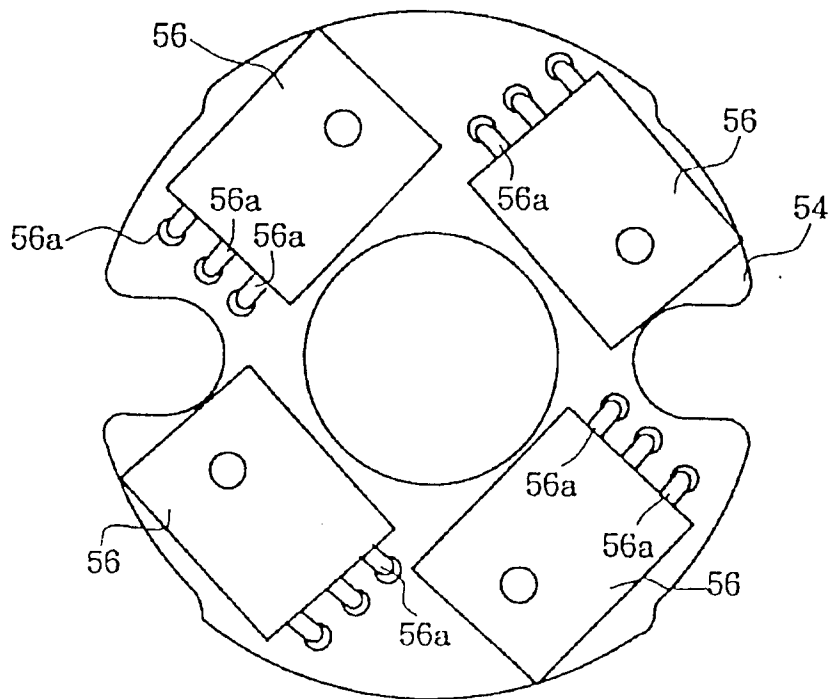


FIGURE 18

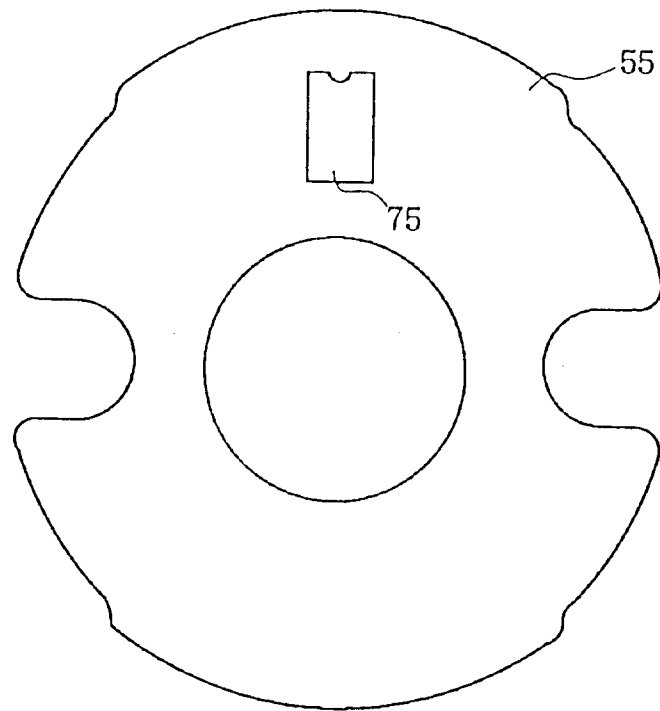


FIGURE 19

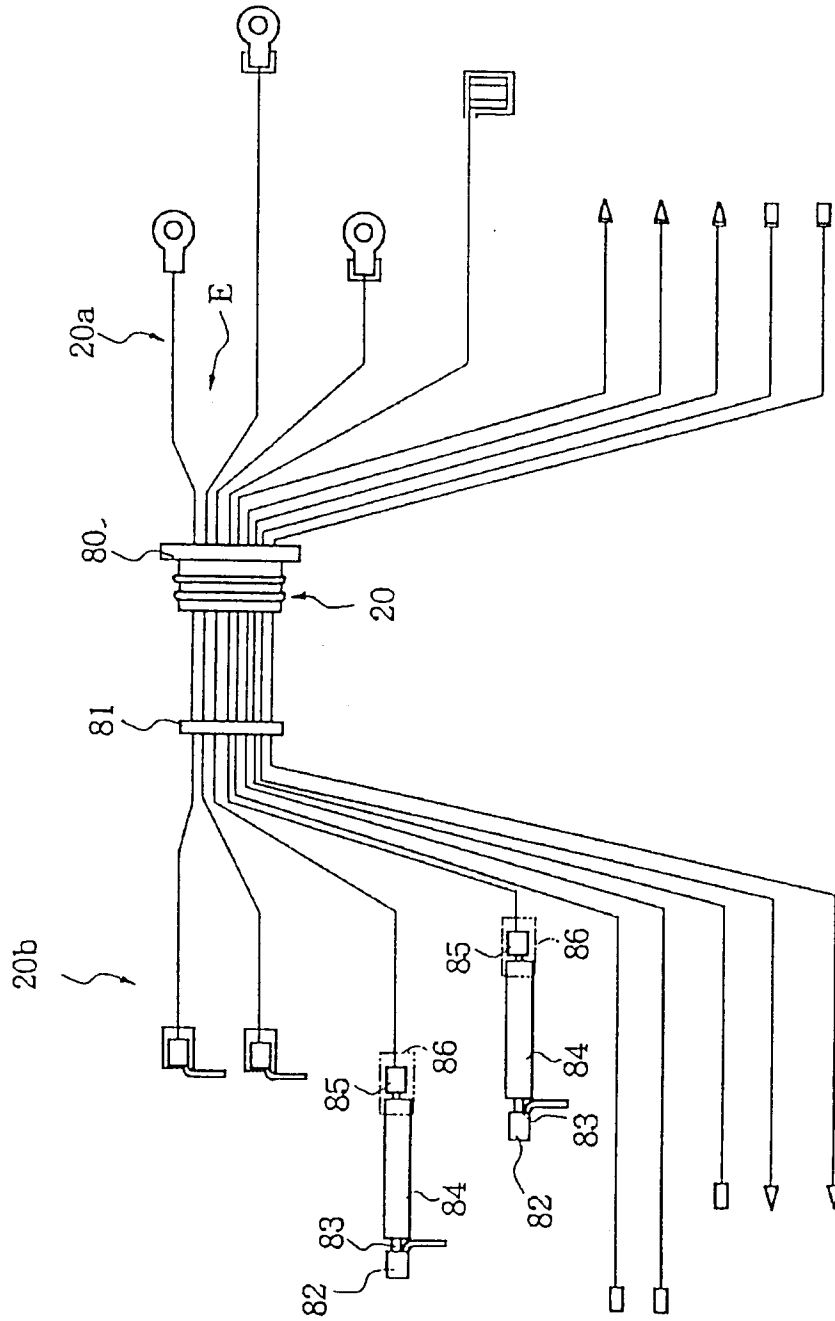


FIGURE 20

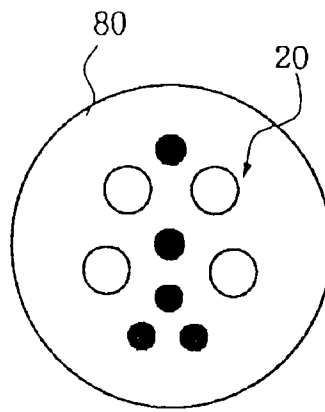


FIGURE 21

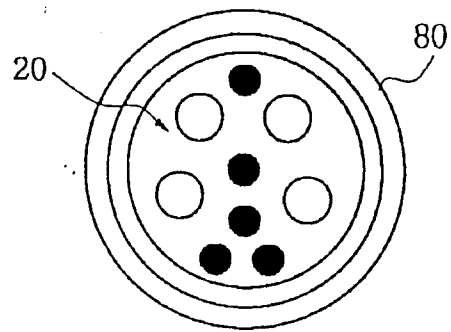


FIGURE 22

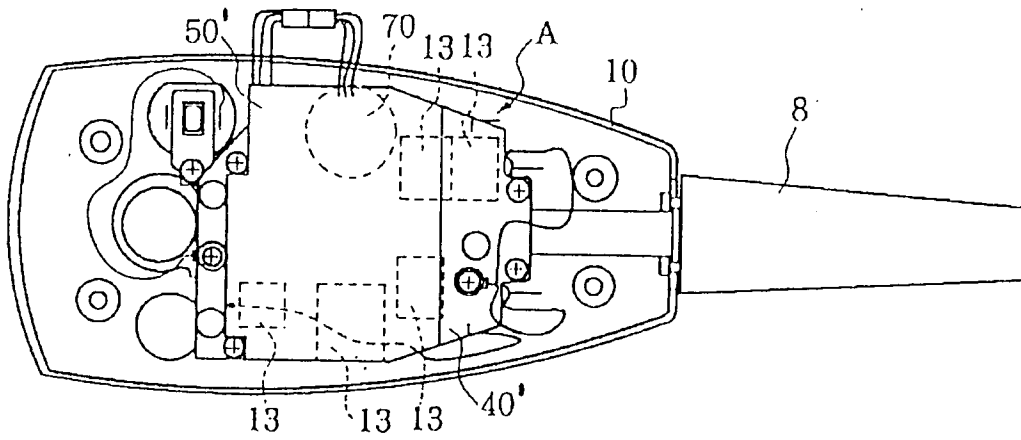


FIGURE 23(a)

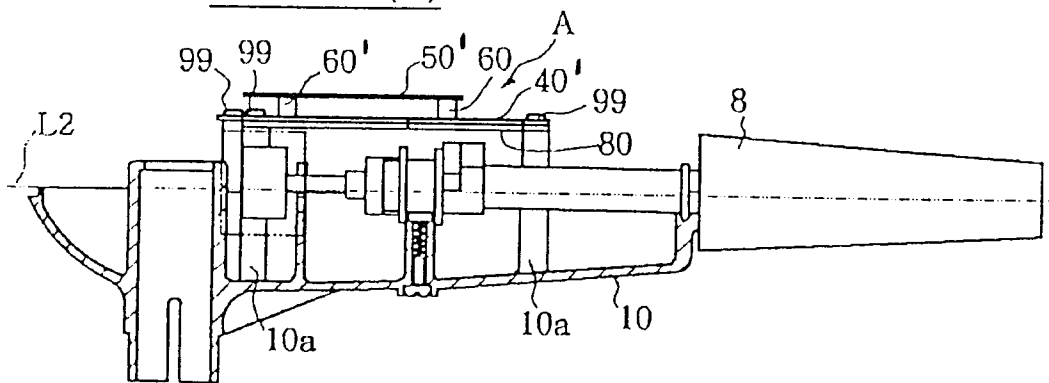


FIGURE 23(b)

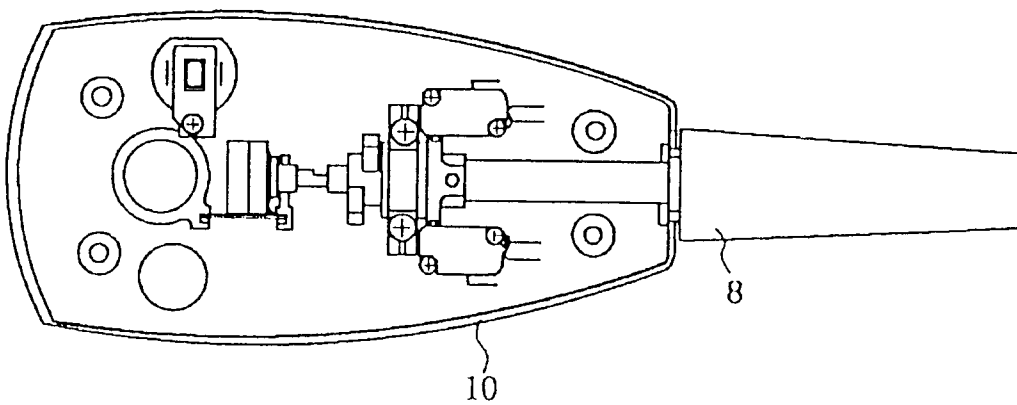


FIGURE 23(c)

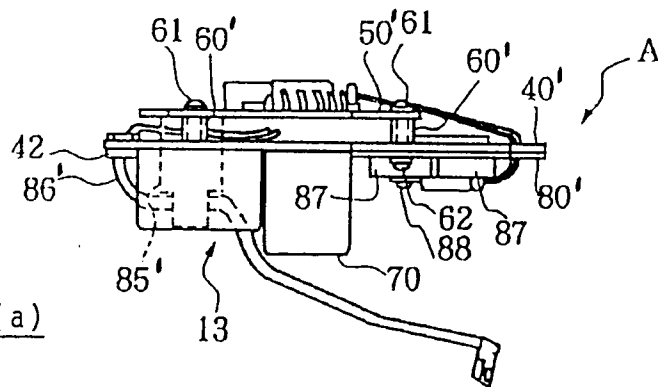


FIGURE 24(a)

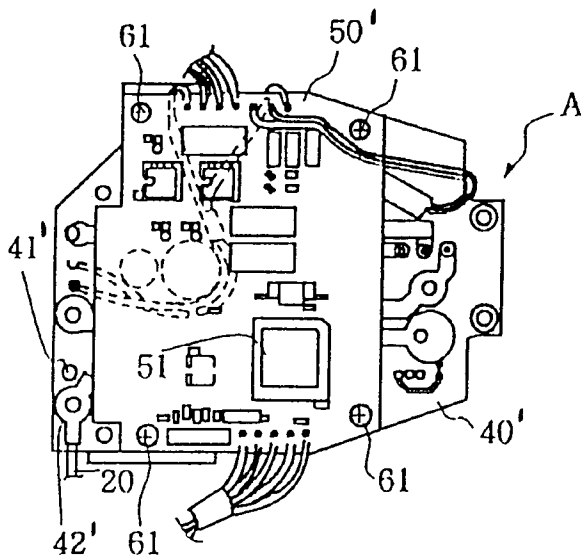


FIGURE 24(b)

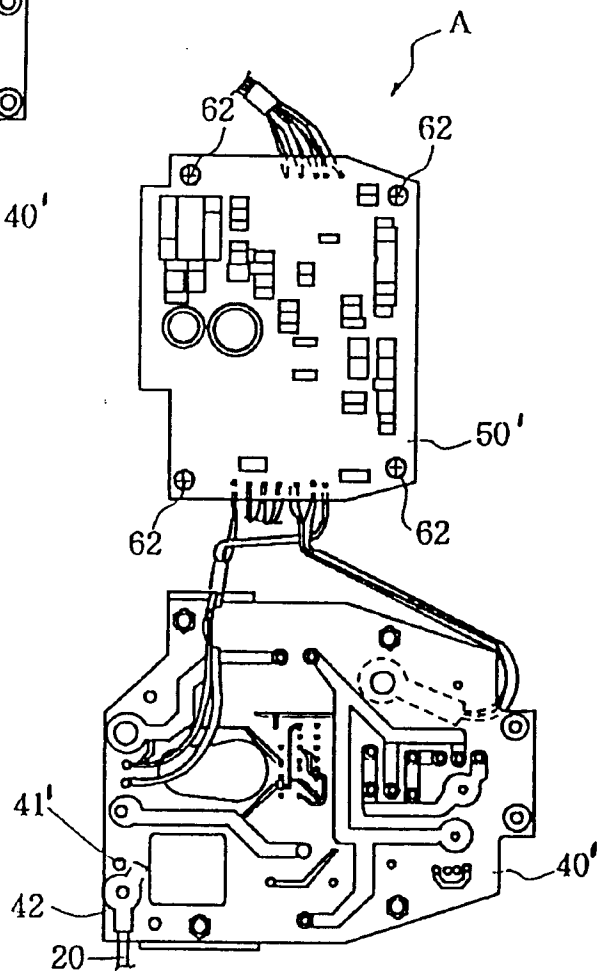


FIGURE 24(c)

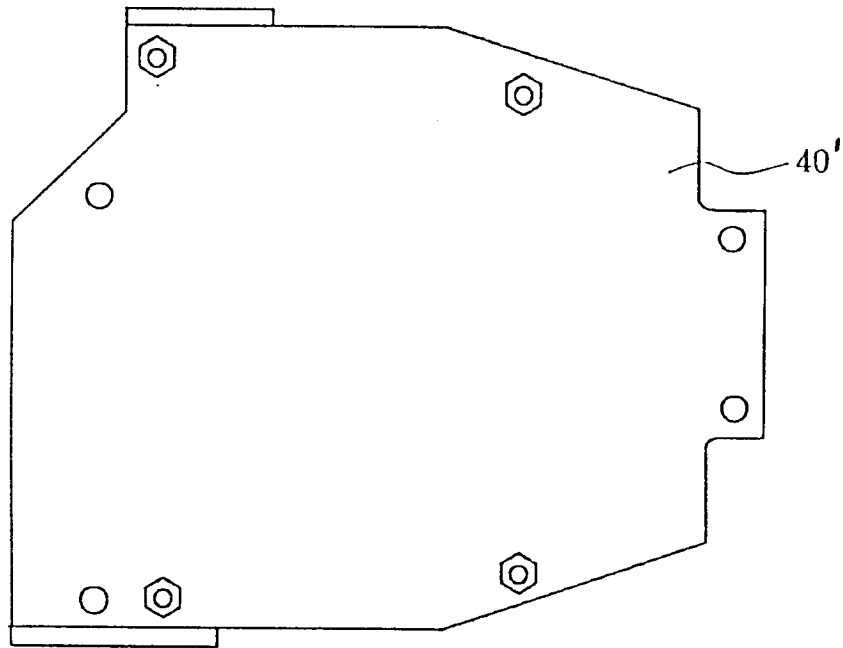
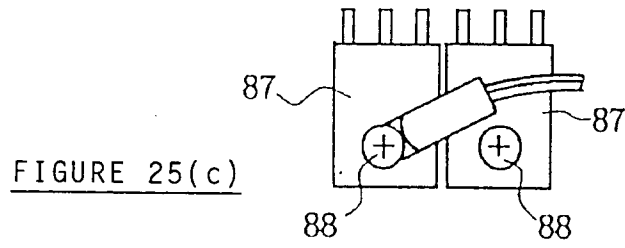


FIGURE 25(b)

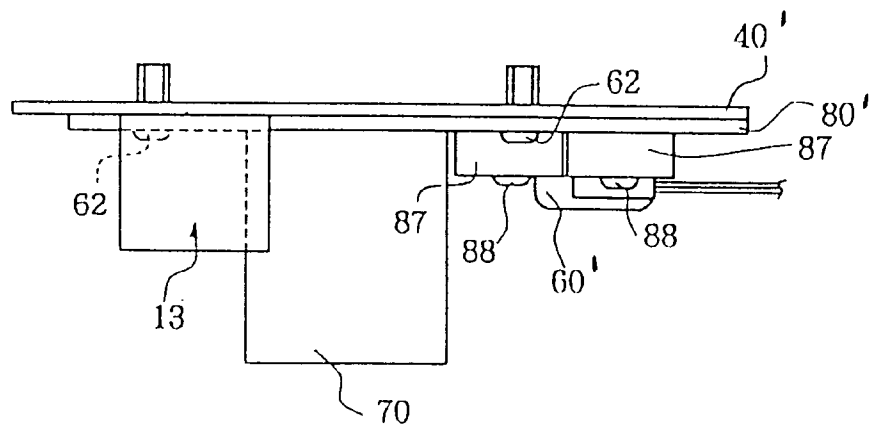


FIGURE 25(a)

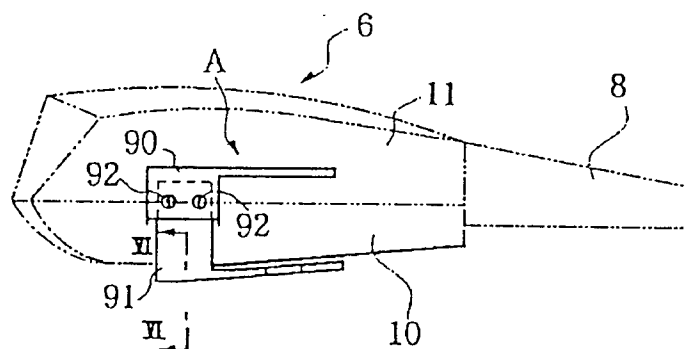


FIGURE 26(a)

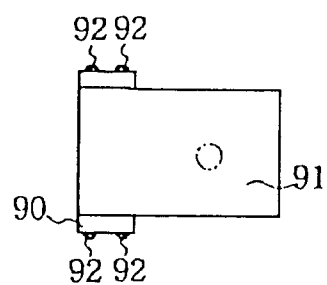


FIGURE 26(b)

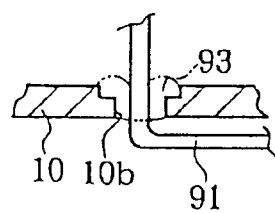


FIGURE 26(c)

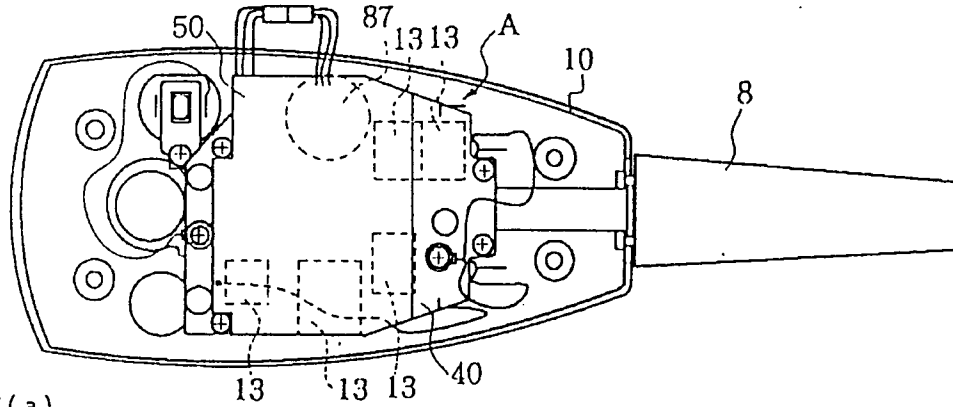


FIGURE 27(a)

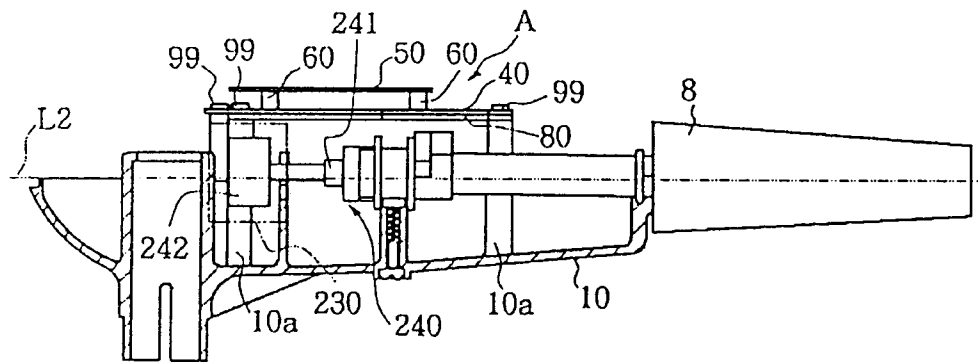


FIGURE 27(b)

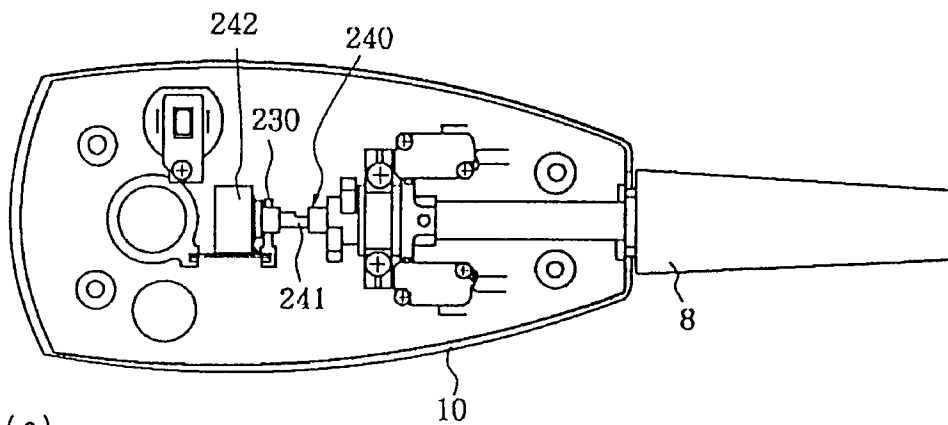


FIGURE 27(c)

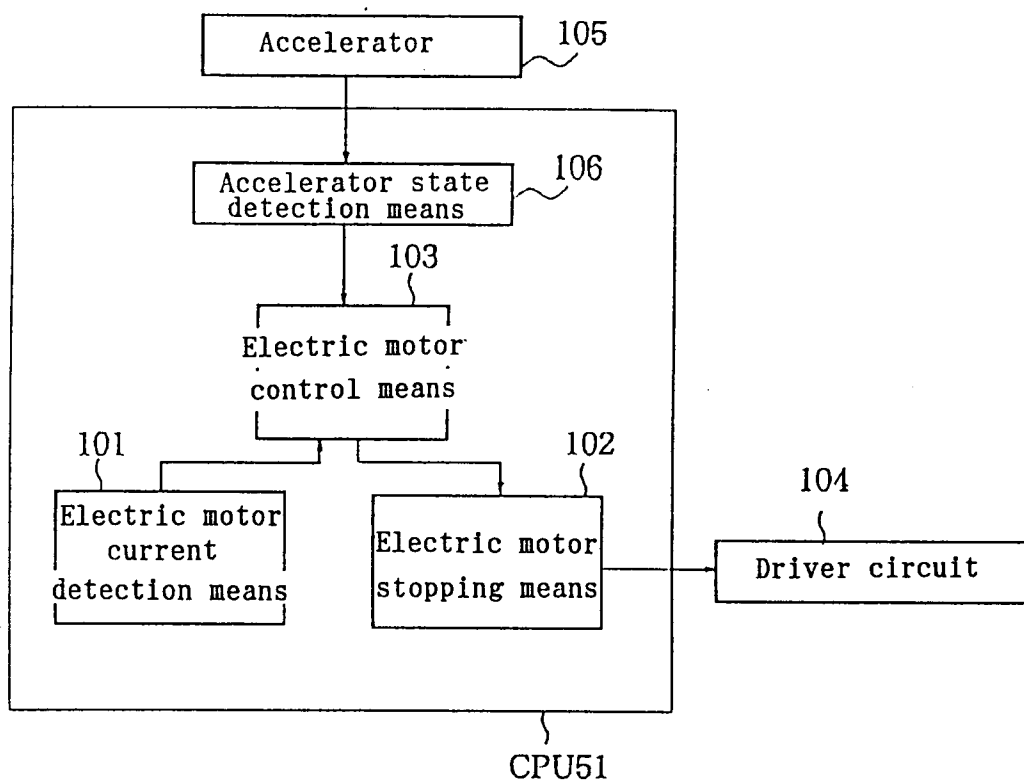


FIGURE 28

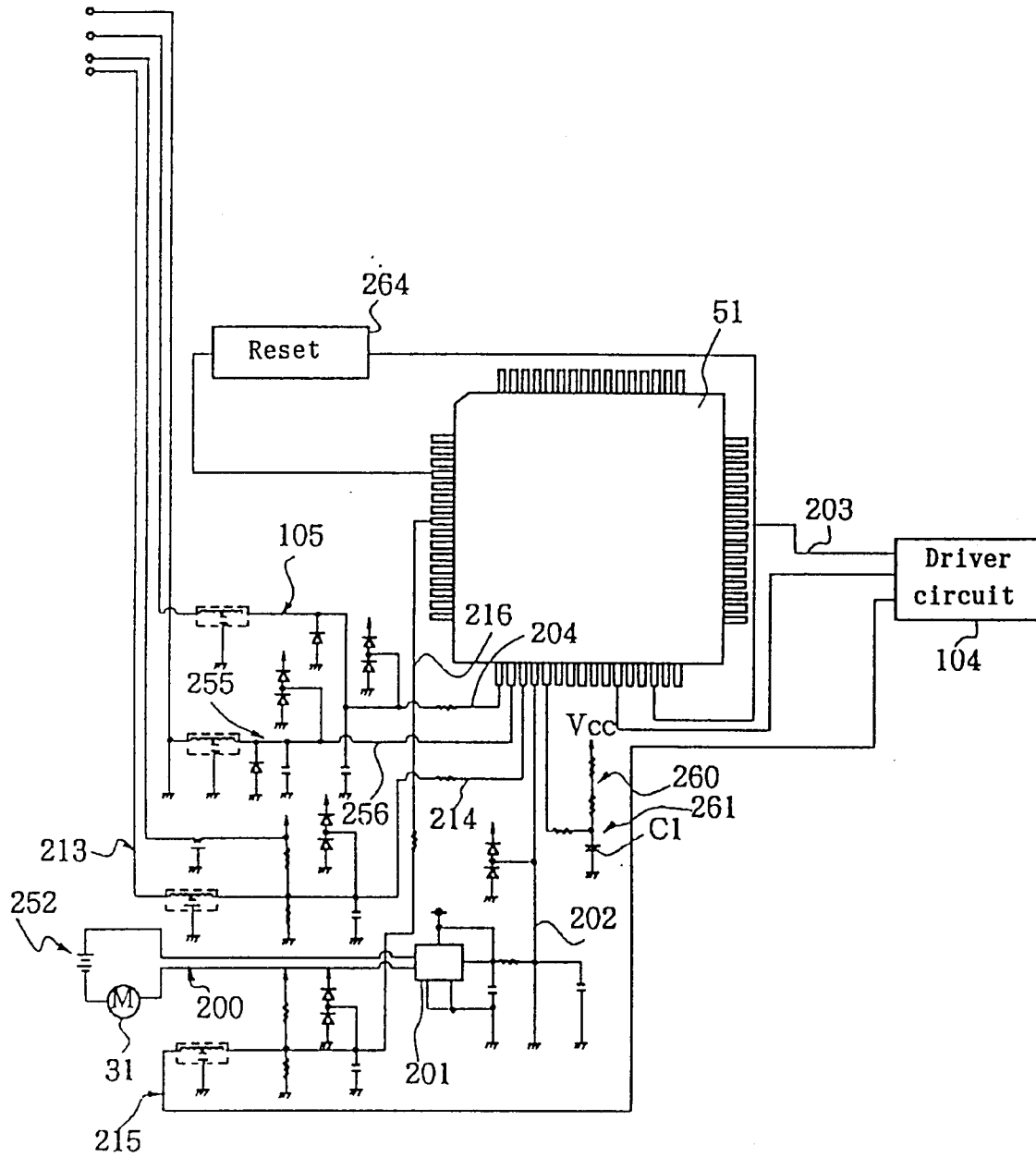


FIGURE 29

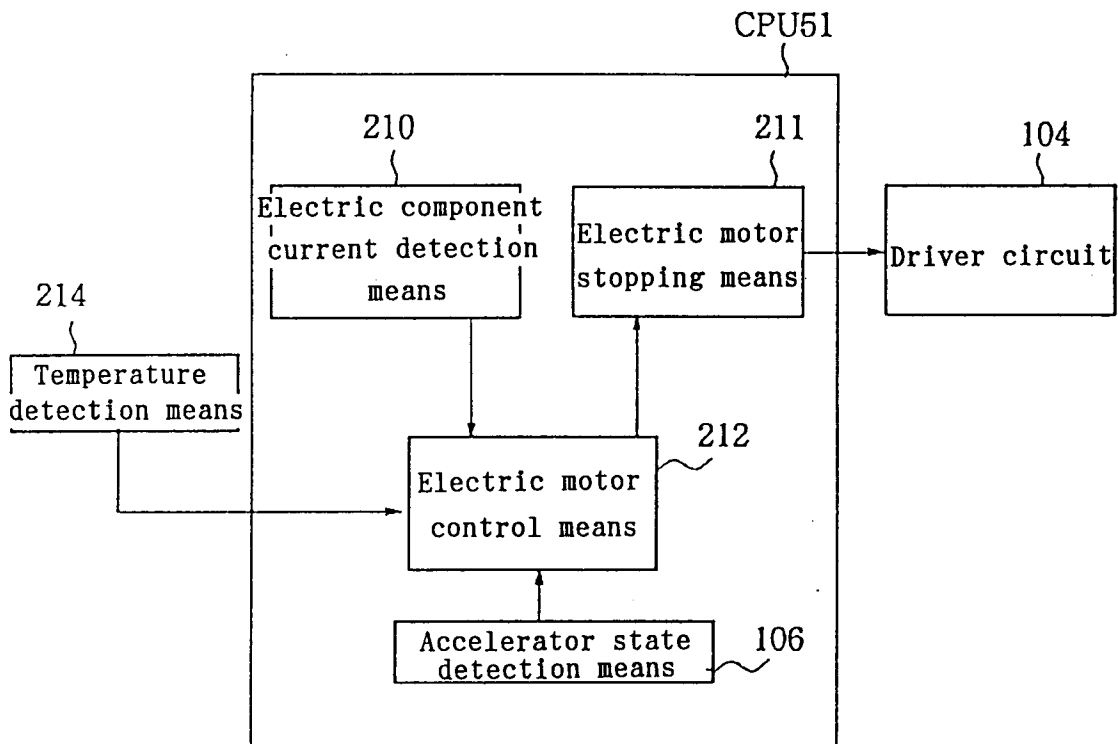


FIGURE 30

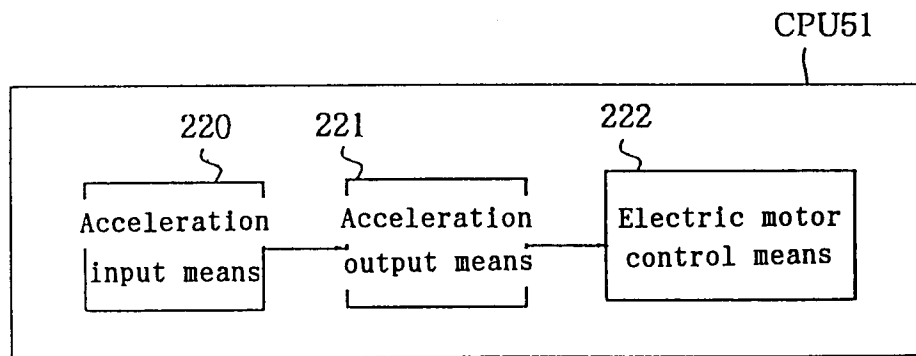


FIGURE 31

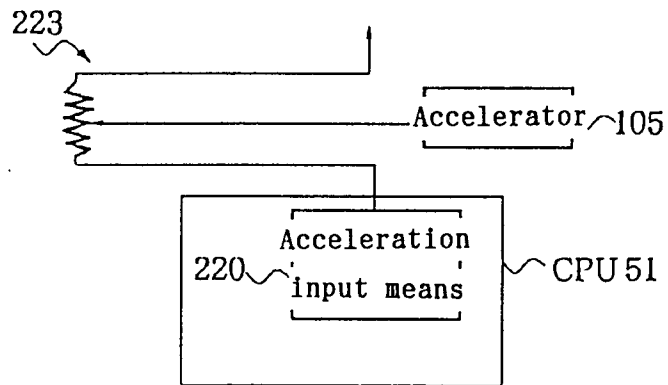


FIGURE 32(a)

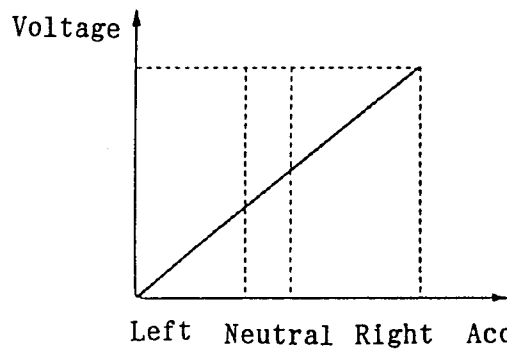


FIGURE 32(b)

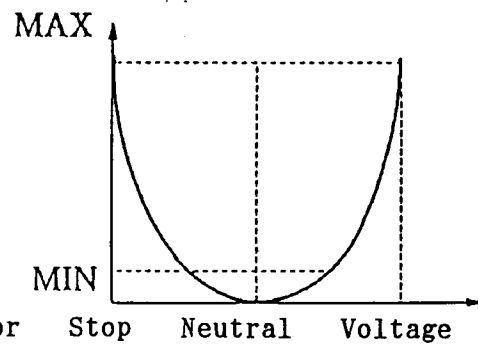
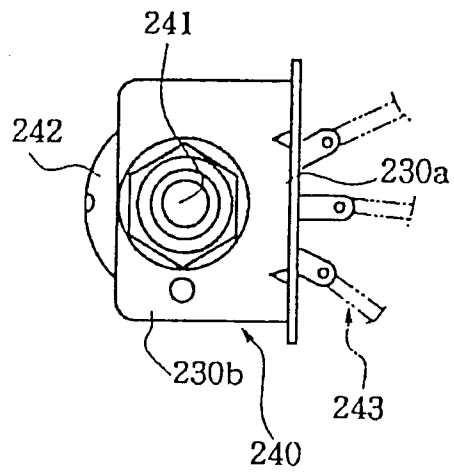
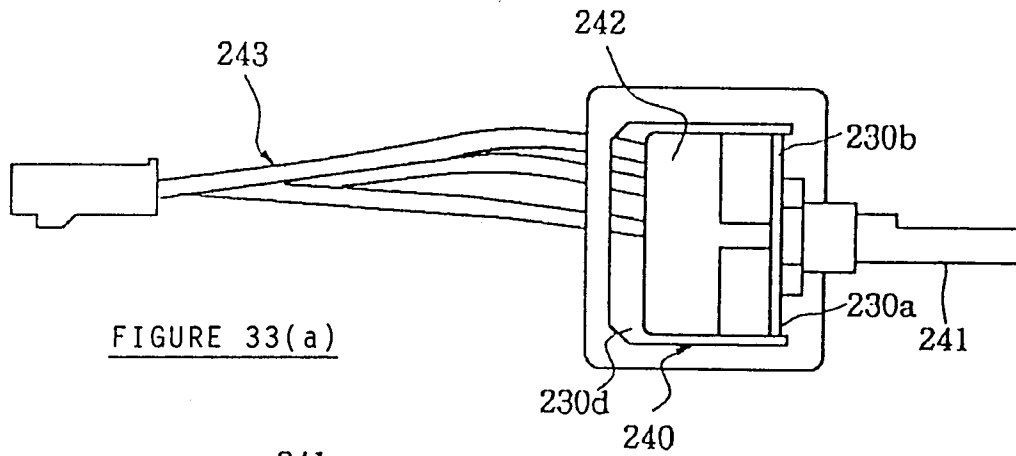


FIGURE 32(c)



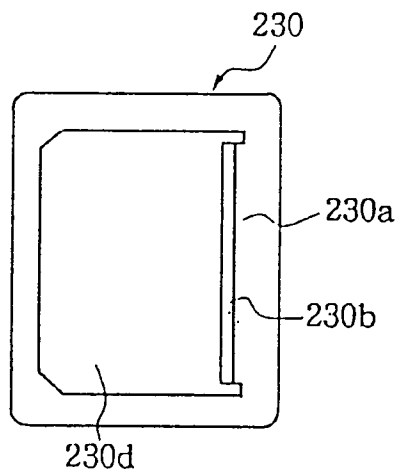


FIGURE 34(a)

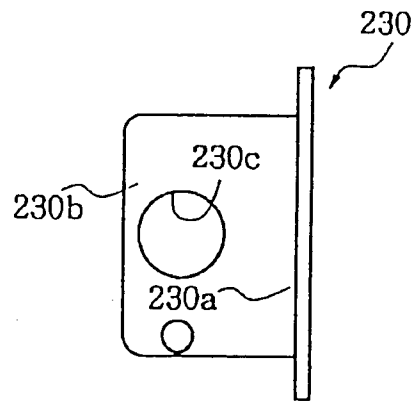


FIGURE 34(b)

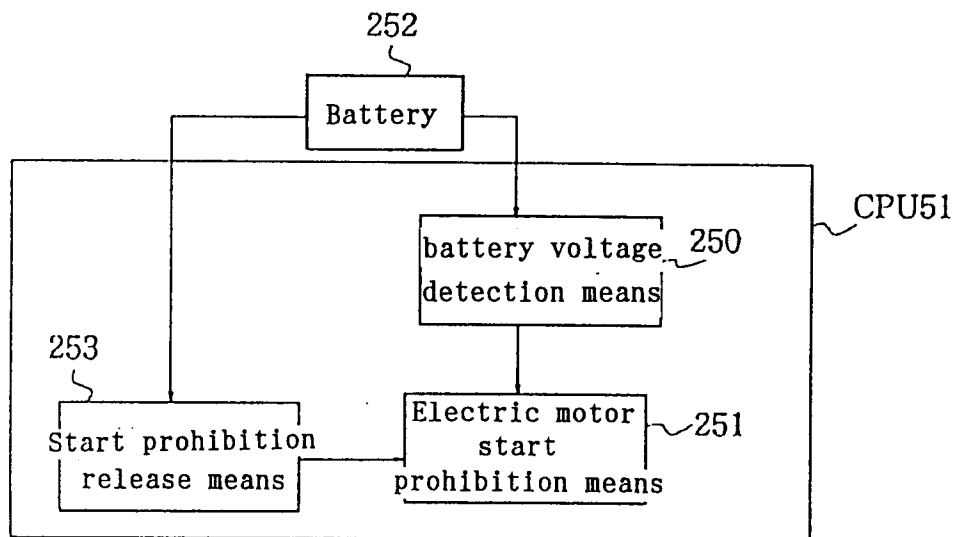


FIGURE 35

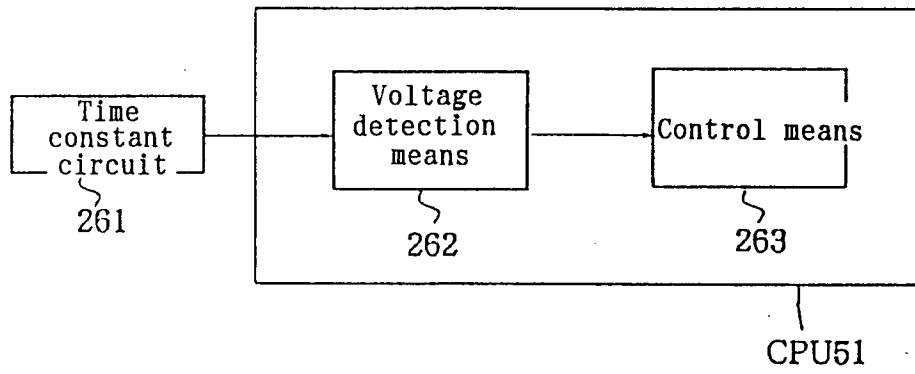


FIGURE 36

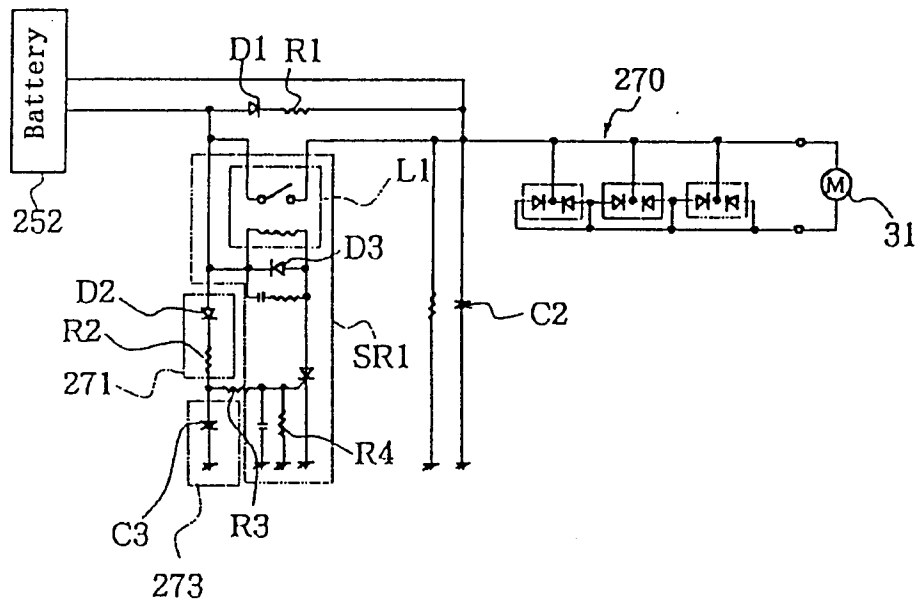


FIGURE 37



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 8850

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)
X A	US 3 906 887 A (C.KAPPAS) * abstract; figures * * column 3, line 57 - column 4, line 19 * ---	1,6 2,4,5	B63H20/00
X A	US 5 171 173 A (W.HENDERSON) * column 5, line 12 - line 48; figures * ---	1 2,8	
A	GB 2 142 492 A (OUTBOARD MARINE CORPORATION) * abstract; figures * -----	1,16	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B63H
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 25 February 1997	Examiner Stierman, E
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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