A Model of Amusement Park in the Near Future Operated by Fuel Cell and Solar Cell

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Abstract
Now-a-days, global warming, caused by the burning of fossil fuel, has been attributed to unusual weather conditions in the world and the melting of ice in the Arctic Ocean. In order to address this global challenge, there have been various activities in almost every society. Solar cells and fuel cells using clean energies are actively applied to the generation of electricity in homes and electric vehicles instead of using fossil fuel. Recently, solar generation systems, with a capacity of 30 kW have been installed in Huis Ten Bosch as an electric source for the theme park. However, teaching materials that are easy to understand regarding the use of clean energies are not generally used in elementary schools. Handicrafts and experiments using clean energies are especially required at an early time for schoolchildren from the viewpoint of ecology. This paper proposes a model of an amusement park in the near future operated by clean energies as teaching materials of elementary schools. Handicrafts using clean energies are a cable car operating on a fuel cell aided by a solar cell, a balloon tower and an electric train operated by a fuel cell.

Keywords
global warming, schoolchildren, amusement park in the near future, handicrafts using solar cell and fuel cell, global environmental protection

1. INTRODUCTION
In 1997, the Kyoto Protocol (COP3) established legally binding commitments for the reduction of greenhouse gases. Under the Kyoto Protocol, industrialized countries agreed to reduce their collective greenhouse gas emissions by 5.2 % compared to the year 1990. National limitations range from 6 % reductions for Japan over the 2008 to 2012 period.

These days, as a consequence of global warming, glaciers in Greenland have receded considerably and polar bears in that area have been driven to the extreme edge of subsistence caused by the melting of ice in the Arctic Ocean, which is the prime hunting ground for the bear. Furthermore, climate change has produced unusual weather conditions in the world resulting in massive floods caused by localized downpours on one hand and severe drought, large scale forest fire, major typhoons (hurricanes) and damage of marine organisms on the other. Recently, there have been many proposals and countermeasures for the purpose of global environmental protection. For instance, solar cells and fuel cells using clean energies are actively applied to the generation of electricity in homes and electric vehicles instead of using fossil fuel. However, teaching materials that are easy to understand regarding the use of clean energies are not generally used in el-

ementary schools. Handicrafts and experiments using clean energies are especially required at an early time for schoolchildren from the viewpoint of environmental protection based on global warming [Yamaguchi, 2008].

This paper proposes a model of an amusement park in the near future operating on clean energies as teaching materials of elementary schools. Handicrafts using clean energies are a cable car operating on fuel cell aided by a solar cell, a balloon tower and an electric train operated by a fuel cell.

2. A MODEL OF AN AMUSEMENT PARK IN THE NEAR FUTURE
It is expected that the power sources of mechanical amusement devices for amusement parks in the near future would naturally be clean energies based on fuel cells and solar cells. The handicrafts, as models of amusement machines, are mounted in the model of the amusement park.

A general view of a model of an amusement park in the near future is shown in Figure 1. Firstly, two land areas with the height of 30 mm are made of papier-mâché on a sheet of 1500 mm × 900 mm × 11 t plywood, and they are connected to two bridges with the length of 220 mm and the height of 155 mm. In the model of amusement park, an electric train (3), operating on a fuel cell, runs on the track with a distance of 3.5 m around. Furthermore, a balloon tower (1) and a ferris wheel (6) operating on a fuel cell, a cable car (2) operating on a fuel cell aided by a solar cell, a
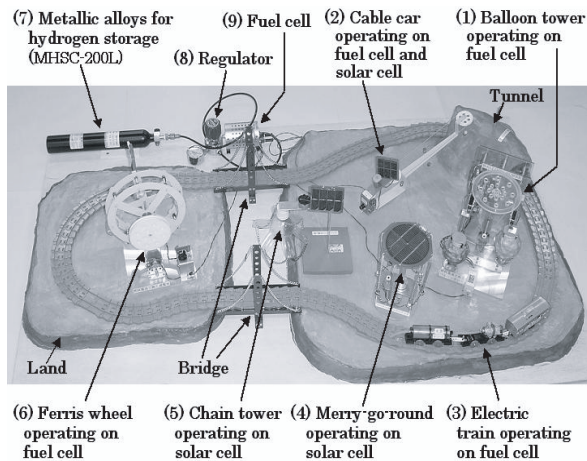
Fig. 1 General view for a model of amusement park in the near future operating on fuel cell and solar cell

chain tower (5) and a merry-go-round (4) operating on a solar cell, are mounted. The Ferris wheel (6), chain tower (5) and merry-go-round (4) are already reported by Yamaguchi [2008]. This paper deals with the balloon tower (1) and cable car (2).

3. BALLOON TOWER OPERATING ON FUEL CELL

A general view of the balloon tower operating on a fuel cell is shown in Figure 2. Balloon A (7) and bal-
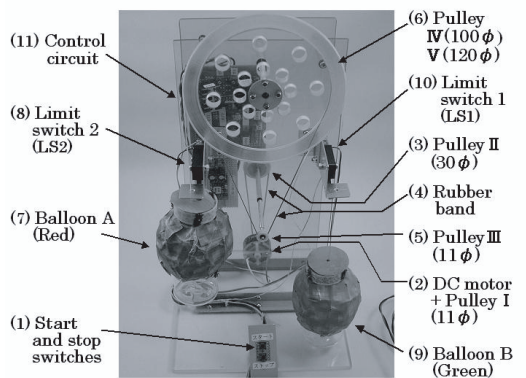
(a) Front view of balloon tower
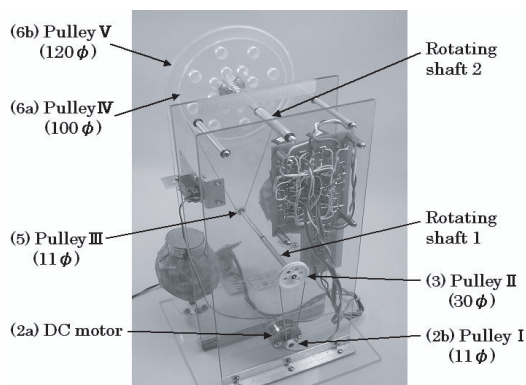
(b) Rear view of balloon tower

Fig. 2 General view of balloon tower

loon B (9) of the balloon tower repeat their up and down movement constantly like a see-saw. Firstly, the power source of the balloon tower is supplied from a fuel cell with the capacity of 5 W (5 V × 1 A). The start switch and the stop switch (1) are composed of two microswitches with a push button. The DC motor (2a) is RF-500TB with a rated voltage of 5 V made by Mabuchi Motor. Pulley I (2b) is installed to the shaft of the DC motor, and they are connected to pulley II (3) of the rear side installed to rotating shaft 1 by a rubber band.

Pulley III, (5) of the front side installed to rotating shaft 1 is connected to pulley IV (6a), installed to rotating shaft 2 by a rubber band (4). Up and down motions for balloon A (7) and balloon B (9) are carried out by a lead polyester thread double wound through a pulley V (6b). A double pulley (6), with diameters of 120 ϕ and 100 ϕ, are made of acrylic board with the thickness of 8 mm using a lath, and the pulley's weight was reduced by drilling 7 holes of 10 ϕ, and 8 holes of 8 ϕ each on the acrylic board. Reduction ratio between pulley I (2b) and pulley V (6b) is about 1/25 in order to realize the smooth motion of the balloons. Limit switch 2 (8) and limit switch 1 (10) are used for sensing and stopping the upward motion of the two balloons. A view of the mounting limit switch 2 and limit switch 1 is shown in Figure 3. Balloon A is stopped by contact with limit switch 2, and balloon B is stopped by contact with limit switch 1. The two limit switches are mounted on bended aluminum boards.
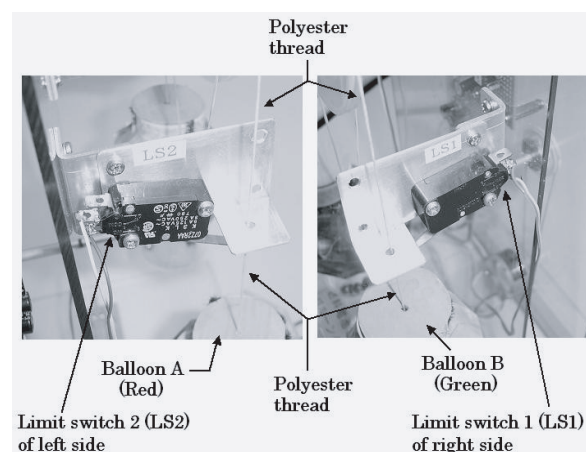

Fig. 3 A view of mounting for limit switch 2 and limit switch 1

A block diagram of the balloon tower operating on a fuel cell is shown in Figure 4. When the starting button is pushed ON, the starting circuit is operated at once. As a result, the DC motor is rotated clockwise by the driving circuit, and balloon A moves upward. Consequently, balloon B moves downward. As balloon
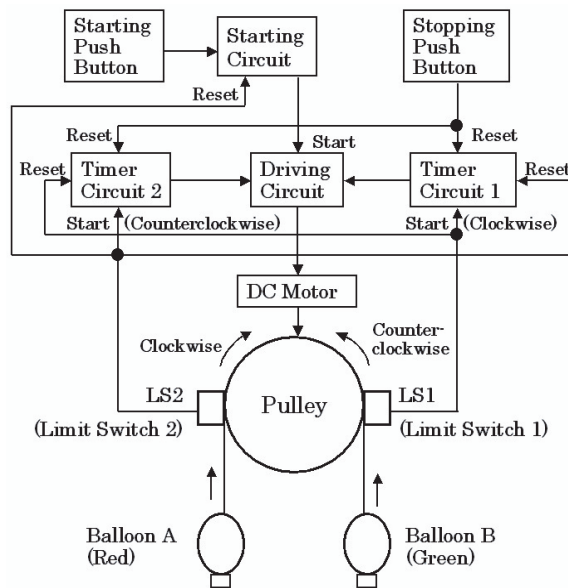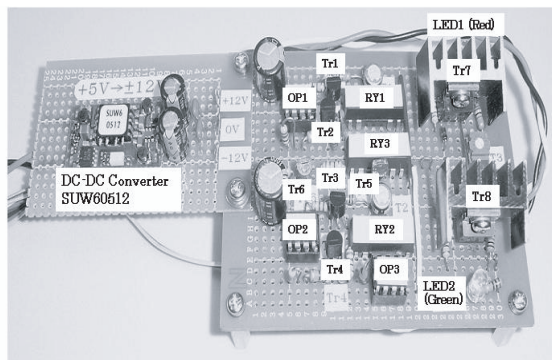
Fig. 4 Block diagram of the balloon tower operating on fuel cell

OP1~3 (Operational Amplifier) : μA741
Tr1, Tr3 (Transistor) : 2SA562
Tr2, Tr4 ~ Tr6 (Transistor) : 2SC1959   RY1~3 (Relay) : RRD52A12(D)
Tr7 (Transistor) : 2SC2238A   LED1 (Light Emitting Diode) : OSHR5111A (Red)
Tr8 (Transistor) : 2SA968B   LED2 (Light Emitting Diode) : OSPG5111A (Green)

Fig. 5 General view of control circuit for the balloon tower

A is contacted with limit switch 2 (LS2), timer circuit 2 is operated. After a preset time of 2 s on the timer circuit 2, the DC motor is rotated counterclockwise by the driving circuit, and balloon B is motioned upward, while balloon A moves downward. Setting times of timer circuits 1 and 2 can be adjusted at a time range from 1.6 s to 5 s, resulting in the similar adjustment on the upward and downward motion of the balloon tower. When the stopping button is pushed ON, timer circuits 1 and 2 are reset at once. As a result, balloons A and B are stopped at their positions because the DC motor is turned off by the off signal from the driving circuit. A general view of the control circuit for the balloon tower is shown in Figure 5.

The control systems of the balloon tower consist of relay sequence control by a combination of relay,

transistor and operational amplifier. A DC-DC converter with type SUW60512 made by COSEL is used in order to convert the power source +5 V from the fuel cell to ±12 V of power source for the control circuit. Operational amplifiers OP1-2 with type μA741 are used as timers. In the same way, OP3 is used as a voltage follower. The transistors of Tr1-6 with types 2SA562 and 2SC1959 are used to drive the reed relay (RRD52A12D) of RY1-3 as a switching device. Power transistors Tr7-8 with types 2SA968B and 2SC2238A are used to drive the DC motor as a complementary push-pull circuit without cross-over distortion. As a monitor of operation for the balloon tower, a red LED is turned on when balloon A (red balloon) is moved upward, and a green LED is turned on when balloon B (green balloon) is moved upward. Power consumption of the balloon tower is 2.64 W (4.8 V × 0.55 A) at the maximum value.

4. CABLE CAR OPERATING ON FUEL CELL AIDED BY SOLAR CELL

A general view of the cable car operating on a fuel cell aided by a solar cell is shown in Figure 6. In a similar way to the balloon tower, the main power source of the cable car is supplied by line switch (1) from a fuel cell with (5 V × 1 A). For the DC motor (2) both FC-280SA and RF-500T-12580 by Mabuchi Motor can be used. Pulley I (3) is installed to the shaft of DC motor, and they are connected to pulley II (4) by a rubber band with the length of 8 cm. Furthermore, Pulley III (4) is connected to pulley IV (5) with the length of 14 cm, and pulley V (5) is connected to pulley VI (6) by a rubber band with the length of 50 cm. Reduction ratio between pulley I (3) and pulley VI (6) is about 1/12. A series-type regulator by a combination of transistor and Zener diode is used for the speed control circuit (9) of the DC motor (2). The capacity of a solar cell (10) for the hybrid system is 0.375 W (1.5 V × 0.25 A).
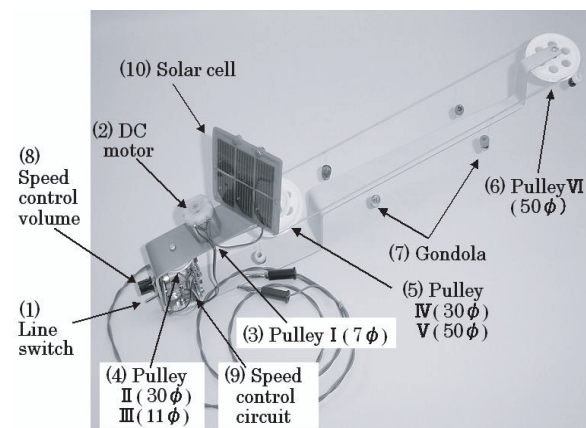

Fig. 6 General view of cable car operating on fuel cell aided by solar cell

The electric characteristics and time required for a round of gondola with the cable car is shown in Table 1. In case of operating on fuel cell only, supplying electric power P_S ($E_G \times I_S$) and time required for a round of gondola tr are investigated for the position of speed control square for the position corresponding to Min.-1/2 of the volume. The time required for a round of the gondola t_r is decreased rapidly based on the characteristics of the speed control volume. On the other hand, supplying electric power P_S is increased slightly.

Table 1 Characteristics of the cable car

	Operating a fuel cell only			Operating a fuel cell aided by solar cell		
Position of speed control volume	Time required for a round of gondola t_r (s)	Generating voltage of a fuel cell E_G (V)	Supplying current to a cable car I_S (mA)	Time required for a round of gondola t_r (s)	Generating voltage of a fuel cell E_G (V)	Supplying current to a cable car I_S (mA)
Min.	22	4.31	87	14.8	4.73	63
1/4	9.6	4.33	88	7.7	4.69	67
1/2	5.5	4.16	103	5.1	4.35	82
3/4	4.4	3.49	167	4.3	3.54	163
Max.	4.2	3.28	208	4.1	3.29	205

In the case of the hybrid system, based on operating a fuel cell aided by a solar cell, intensity of illumination equivalent to 3300 lx of reflector lamp with 100 W is radiated to the solar cell (10). As a result, supplying electric power P_S from the fuel cell is decreased to about 18 % compared to operating on a fuel cell only for the position corresponding to Min to 1/2 of speed control volume. That is, supplying electric power corresponding to 18 % is equivalent to generating voltage of the solar cell. The time required for a round of the gondola t_r is decreased to about 26 % compared to operating on a fuel cell only for the position corresponding to Min to 1/4 of speed control volume.

5. FUEL CELL SYSTEM

A general view of the fuel cell system used for the balloon tower and cable car is shown in Figure 7. Fuel cell (1) is PFC0505.N with rated electric power of 5 W (5 V × 1 A) made by Daido Metal. The method of sending O_2 in air into the fuel cell is carried out by natural aspiration. Gas pressure of H_2 sent to the fuel cell is adjusted to 0.04 MPa as an indication of pressure gauge (4) using a regulator (3). A fluoric resin tube (5) connecting the fuel cell and regulator is easily removable. Metallic alloys for hydrogen storage MHSC-200L (2) filled-up to capacity of 200 NL with a pressure of 1 MPa is used, made by Japan Steel Works.
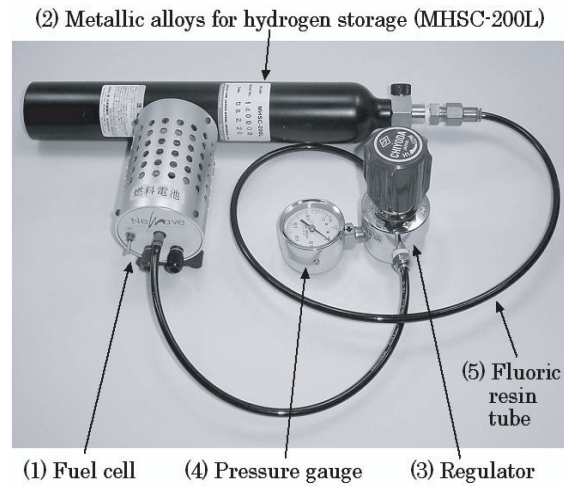

(2) Metallic alloys for hydrogen storage (MHSC-200L)

(1) Fuel cell   (4) Pressure gauge   (3) Regulator

(5) Fluoric resin tube

Fig. 7 General view of fuel cell system

6. CONCLUSION

This paper proposes a model of an amusement park in the near future operating on clean energies as teaching materials based on global warming for elementary schools. Handicrafts using clean energies are a cable car operating on a fuel cell aided by a solar cell and a balloon tower operating on a fuel cell.

As a result, the following have been obtained.

(1) Handicraft of a cable car operating on a fuel cell aided by a solar cell is made easily. Energies generated by the fuel cell and the solar cell can be understood easily by schoolchildren through the experiment.

(2) As the handicraft of the balloon tower using a fuel cell is complicated, method and assembly operation of the handicraft must be investigated further.

Reference
Yamaguchi, S., An examination of handicrafts using clean energy for schoolchildren, *Journal of Asian Electric Vehicles*, Vol.6, No.1, 1087-1091, 2008.