

DESCRIPTION**5 EXTERNAL OPERATION DEVICE AND ENTERTAINMENT SYSTEM****10 FIELD OF THE INVENTION**

 This invention relates to an external operation device that is suitable as a game controller connected to a game machine main unit.

15 BACKGROUND OF THE INVENTION

 Conventionally, with game controllers the game is played while communicating with the game machine main unit by sending the operation information input from the user and informing the user by receiving feedback information sent
20 from the game machine main unit. The game controller has a controller main unit as an operation means, a cable as a data transmission means, and a connector for connecting the cable to the game machine main unit, and data is exchanged in sequence through the cable and connector.

25 A conventional cable cross-sectional view is shown in Figure 1. This cable has multiple electrically conductive wires 1A-1H for conveying electrical signals; among them, electrical conductive wire 1A is arranged on the central

axis of the cable, and electrically conductive wires 1B-1G are arranged around it so as to be adjacent to this electrically conductive wire 1A. The periphery of these electrically conductive wires 1B-1G is covered with
5 electrically conductive wire 1H, and the periphery of electrically conductive wire 1H is covered by vinyl cover 1I, thereby forming a rodlike shape.

The periphery of each of electrically conductive wires 1A-1G is covered with an insulating substance, preventing
10 them from coming into contact with each other and shorting. The cable is covered with mesh-woven electrically conductive wire 1H that gives the periphery of electrically conductive wires 1A-1G a cylindrical shape, and its periphery in turn is covered with vinyl cover 1I,
15 which is an insulating substance, thereby protecting the interior of cable from external physical forces and electromagnetic-wave noise.

A serial communication method for avoiding the effects due to the noise from outside is adopted as the
20 communication method between the game machine main unit and the controller main unit. Generally with a serial communication method, in many cases one electrically conductive wire each is provided for sending and receiving data, and three electrically conductive wires are provided

for controlling the communication. Therefore in the cable,
electrically conductive wires 1A and 1B are taken as
electrically conductive wires for sending and receiving data,
and electrically conductive wires 1C-1E are taken as
5 electrically conductive wires for controlling the
communication.

Electrically conductive wire 1A is an electrically
conductive wire for transmitting data RXD from the
controller main unit to the game machine main unit, and
10 electrically conductive wire 1B is an electrically
conductive wire for transmitting data TXD from the game
machine main unit to the controller main unit. Electrically
conductive wire 1C is an electrically conductive wire for
transmitting communication standard clock SCK from the game
15 machine main unit to the controller main unit, electrically
conductive wire 1D is an electrically conductive wire for
transmitting communication enable signal DTR from the game
machine main unit to the controller main unit, and
electrically conductive wire
20 1E is an electrically conductive wire for transmitting
communication completion signal DSR from the controller main
unit to the game machine main unit.

Electrically conductive wire 1F is an electrically
conductive wire for an 8-V power source that operates the

lamps, etc. formed on the controller main unit, electrically
conductive wire 1G is an electrically conductive wire for
power source Vcc that determines the signal level of logical
level "1," and electrically conductive wire 1H is an
5 electrically conductive wire for grounding line GND that
determines the signal level of logical level "0".

In cables such as shown in Figure 1, direct current
flows in electrically conductive wires 1F-1H, while
high-frequency alternating current flows in electrically
10 conductive wires 1A-1E. Therefore, no noise due to
electromagnetic waves (hereafter called electromagnetic-wave
noise) arises from electrically conductive wires 1F-1H, but
electromagnetic-wave noise does arise from electrically
conductive wires 1A-1E. A number of adverse effects have
15 been pointed out concerning this noise, and the upper limit
for the level of its occurrence is strictly prescribed by
domestic and international standards.

For this reason, in such cables the electromagnetic-
wave noise is reduced by covering the periphery of
20 electrically conductive wires 1A-1E with mesh-woven
electrically conductive wire 1H, and in turn covering the
periphery of electrically conductive wire 1H with vinyl
cover 1I, which is made of an insulating substance. However,
because this is unable to sufficiently reduce the

electromagnetic-wave noise, in general the generation of electromagnetic-wave noise is avoided by putting a noise shield on cable 1.

The level of occurrence of electromagnetic-wave noise increases as the frequency increases. But the capacity of a noise shield is limited, and it is unable to suppress electromagnetic-wave noise above a certain level. Therefore even if cable 1 is fitted with a noise shield, as the frequency of the alternating current flowing in electrically conductive wires 1A-1E increases and electromagnetic-wave noise beyond a certain level is generated, the limit of the noise shield is exceeded, and electromagnetic-wave noise can no longer be suppressed.

Thus there has been the problem that in order to prevent the generation of electromagnetic-wave noise in cable 1, one must limit the frequency of the electric current, that is, the communication speed, and high-speed communication cannot be done. Because the current flowing in electrically conductive wires 1A-1H becomes attenuated as said electrically conductive wires 1A-1H become longer, there has been the problem that there is a limit to the length of electrically conductive wires 1A-1H, that is, of cable 1.

SUMMARY OF THE INVENTION

This invention provides an external operation device that provides communication at higher speed than was previously available

5 The invention provides an operation device which converts electrical signals of a transmission object input in accordance with operation by the user to optical signals by an internal electro-optical signal converter and outputs the optical signals to the operation object. Optical
10 signals transmitted from the operation object are converted to electrical signals by the electro-optical signal converter which outputs the signals to the outside information in accordance with the electrical signals. An optical fiber, one end of which is attached to the operation
15 device transmits optical signals between the operation device and the operation object. A connection means is provided on the other end of the optical fiber and is detachably connected to the operation object which converts optical signals transmitted from the operation device via
20 the optical fiber to electrical signals by an internal electro-optical signal converter and outputs the electrical signals to the operation object, and converts electrical signals supplied from the operation object to optical

signals by the electro-optical signal converter and outputs the optical signals to the operation device.

By connecting the operation device to the operation object via an optical fiber and during communication, converting the electrical signals of the transmission object to optical signals and transmitting the optical signals via the optical fiber, electromagnetic-wave noise during communication is not generated, and there is no need to limit the frequency of the optical signals. That is, the communication speed, as there would be if the operation means were connected to the operation object via electrically conductive wires.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-section view of a conventional prior art cable;

Fig. 2 shows the overall game system according to one embodiment of the invention;

Fig. 3 is a block diagram showing the circuitry of the game system;

Fig. 4 shows a cross-section of the cable of the invention;

Fig. 5 shows the cable twisting testing device of the invention;

Fig. 6 shows the shape of the cable connector;

Fig. 7 shows the external appearance of the cable connector;

Fig. 8 shows the connector connection part of the game
5 machine main unit;

Fig. 9 shows a cross-section of the connector;

Fig. 10 shows the connector tensile strength testing device;

Fig. 11 shows the connector bending strength testing
10 device;

Fig. 12 shows the shape of the controller main unit;

Fig. 13 shows a cross-section of the controller main unit;

Fig. 14 shows the controller main unit tensile strength
15 testing device;

Fig. 15 shows the controller main unit bending strength testing device;

Fig. 16 shows a cross-section of the cable according to another embodiment;

20 Fig. 17 shows a cross-section of the connector according to another embodiment; and

Fig. 18 shows a cross-section of the controller main unit according to another embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In Figure 2, game system 10 is made up of game machine main unit 11 and game controller 12. Game controller 12 has controller main unit 13 as an operation means, cable 14, which adopts an optical fiber as a data transmission means, and connector 15 for detachably connecting said cable 14 to game machine main unit 11. Data is sent and received with game machine main unit 11 via cable 14 and connector 15.

Controller main unit 13 is formed from input unit 16, which consists of buttons 16A-16C, and output unit 17, which consists of lamps. As shown in Figure 3, when the user presses the desired button of input unit 16 among buttons 16A-16C, input unit 16 outputs to electrical/optical signal converter 20 electrical-signal operation information S1 corresponding to the specified content. Electrical/optical signal converter 20 converts electrical-signal operation information S1 to optical-signal operation information S2, which it outputs to connector 15 via the optical fiber of cable 14. Connector 15, which has electrical/optical signal converter 21, converts the input optical-signal operation information S2 to electrical-signal operation information S3 by electrical/optical signal converter 21 and outputs it to game machine main unit 11. Game machine main unit 11 causes the game to proceed in accordance with this

operation information S3 by reflecting the operation information S3 in the content of the game.

In response, game machine main unit 11 outputs to connector 15 feedback information S4 consisting of
5 electrical signals with the desired timing that corresponds to the progress of the game. Connector 15 converts the electrical-signal feedback information S4 to optical-signal feedback information S5 by electrical/optical signal converter 21 and outputs it to electrical/optical signal
10 converter 20 of controller main unit 13 via the optical fiber of cable 14. Electrical/optical signal converter 20 converts optical-signal feedback information S5 to electrical-signal feedback information S6, which it outputs to output unit 17. Output unit 17 lights up or turns off
15 lamps in accordance with feedback information S6.

Figure 4, whose corresponding parts are labeled as in Figure 1, shows a cross-sectional view of cable 14. Cable 14 has optical fibers 14A-14E for transmitting optical signals and electrically conductive wires 1F-1H for
20 transmitting electrical signals. In cable 14, optical fiber 14A is arranged along the central axis of cable 14, and is surrounded by optical fibers 14B-14E and electrically conductive wires 1F and 1G so that they are adjacent to optical fiber 14A.

The periphery of each of electrically conductive wires 1F and 1G is covered with an insulating substance to prevent them from coming into contact with each other and shorting out. In contrast to this, there is no need to cover optical
5 fibers 14A-14E with an insulating substance, because the transmission of optical signals is not affected even if they come into contact with each other. Therefore optical fibers 14A-14E are thinner than electrically conductive wires 1F and 1G, which makes the entire cable 14
10 thinner. Given the desired strength, cable 14 is more flexible the thinner it is, so the ease of use of game controller 12 can be improved by making said cable 14 narrower.

In cable 14, the periphery of optical fibers 14B-14E
15 and electrically conductive wires 1F and 1G is covered with electrically conductive wire 1H, which is mesh-woven into a cylindrical shape, and its periphery in turn is covered with vinyl cover 1I, which is an insulating substance; in this way the interior of cable 14 is protected from physical
20 forces and electromagnetic-wave noise from outside.

A serial communication method for avoiding the influence of noise from outside is adopted as the communication method between game machine main unit 11 and controller main unit 13. Here, cable 14 realizes serial

communication by sending and receiving data using optical fibers 14A and 14B and by exchanging data for controlling the communication using optical fibers 14C-14E.

Optical fiber 14A transmits data RxD from controller
5 main unit 13 to game machine main unit 11. Optical fiber
14B transmits data TxD from game machine main unit 11 to
controller main unit 13. Optical fiber 14C transmits
communication standard clock SCK from game machine main unit
11 to controller main unit 13. Optical fiber 14D transmits
10 communication enable signal DTR from game machine main unit
11 to controller main unit 13. Optical fiber 14E transmits
communication completion signal DSR from controller main
unit 13 to game machine main unit 11.

Electrically conductive wire 1F is an electrically
15 conductive wire for an 8-V power source that operates output
unit 17 of controller main unit 13. Electrically conductive
wire 1G is an electrically conductive wire for power source
Vcc which determines the signal level of logical level "1".
Electrically conductive wire 1H is an electrically
20 conductive wire for grounding line GND which determines the
signal level of logical level "0".

Figure 5 shows twisting testing device 20 which is used
when measuring the strength of cable 14. In twisting
testing device 20, one end of cable 14 is attached to

twisting plate 21. Fixed plate 22 is attached to position P1 located 200 mm from the one end of cable 14, and position P1 of cable 14 is held fast. Twisting device 20 applies a force to cable 14 in the pulling direction by suspending a
5 500-gf load 24 on the other end of cable 14 via pulley 23.

In this state, twisting testing device 20 performs twisting 10,000 times at the rate of 20 times per minute, where one time means a test in which twisting plate is twisted 90 degrees left and right. One then checks for any
10 wire break or other abnormality in optical fibers 14A-14E and electrically conductive wires 1F-1H of cable 14. A cable 14 in which no abnormality is found, is used.

Figure 6 and Figure 7 show the shape of connector 15. Controller main unit 13 is attached to one end of cable 14,
15 and connector 15 is attached to the other end. The user can play the game by connecting connector 15 to game machine main unit 11. Connector 15 consists of insertion part 30, whose outer shell is formed from ABS plastic and which is for inserting into game machine main unit 11, and
20 support part or housing 31, which accommodates an electrical/optical signal converter, etc. Eight signal pins 32A-32H are formed protruding from insertion part 30. Ridge 33 is formed around the periphery of these eight signal pins 32A-32H.

As shown in Figure 8, connector connection part 40 is formed on game machine main unit 11. Controller main unit 13 is detachably connected to game machine main unit 11 by inserting said connector connection part 40 into connector 5 15. Connector connection part 40 consists of eight cylindrical depressions 41A-41H and groove 42, which is formed so as to surround the depressions 41A-41H. Contacts 43A-43H are attached on the side near the base of cylindrical depressions 41A-41H.

10 When the user inserts connector 15 into connector connection part 40 of game machine main unit 11, signal pins 32A-32H are inserted into corresponding depressions 41A-41H and ridge 33 is inserted into groove 42, thereby causing signal pins 32A-32H to make contact and conduct electricity 15 with contacts 43A-43H of depressions 41A-41H.

Figure 9, shows the internal structure of connector 15 which is a cross-sectional view of connector 15. Signal pin 32A transmits data RxD from controller main unit 13 to game machine main unit 11. Signal pin 32B transmits data TxD 20 from game machine main unit 11 to controller main unit 13. Signal pin 32C transmits communication standard clock SCK from game machine main unit 11 to controller main unit 13. Signal pin 32D transmits communication enable signal DTR

from game machine main unit 11 to controller main unit 13.

Signal pin 32E transmits communication completion signal

DSR from controller main unit 13 to game machine main unit

11. Signal pin 32F carries the current of an 8-V power

5 source. Signal pin 32G carries the current of power source

Vcc, and signal pin 32H is for the grounding line GND.

Signal pins 32A-32E are connected respectively to

optical fibers 14A-14E via electrical/optical signal

converters 21A-21E, and signal pins 32F-32H are connected

10 directly to respective corresponding electrically conductive

wires 1F-1H. Among electrical/optical signal converters

21A-21E, electrical/optical signal converters 21A and 21E

convert the optical signals input from optical fibers 14A

and 14E to electrical signals, which it outputs to game

15 machine main unit 11 via signal pins 32A and 32E,

while electrical/optical signal converters 21B, 21C, and 21D

convert the electrical signals input via signal

pins 32B, 32C, and 32D from game machine main unit 11 to

optical signals, which it outputs to optical fibers 14B, 14C,

20 and 14D, respectively.

Optical fibers 14A-14E might not accurately transmit

optical signals unless their bending radius is greater than

a desired value (hereafter called the minimum bending

radius). Therefore it is necessary that in connector 15 the

optical fibers 14A-14E be arranged so that the bending radius of optical fibers 14A-14E is greater than the minimum bending radius.

Specifically, in connector 15, optical fiber guides 51A-51E are arranged in prescribed positions near optical fibers 14A-14E, respectively. Optical fiber guides 51F and 51G are arranged so as to hold between them optical fibers 14A-14E in the prescribed position near cable 14. Optical fibers 14A-14E are arranged along optical fiber guides 51A-51G; this prevents said optical fibers 14A-14E from bending with a radius smaller than the minimum bending radius. In this way, optical fibers 14A-14E and electrically conductive wires 1F-1H are made to converge by optical fiber guides 51A-51G and are accommodated in cable 14. Cable 14 is attached securely to the inside of connector 31 by cable anchoring means 52.

During use, bending stress arises in cable 14 near where it protrudes to the outside from connector 15.

Therefore, in connector 15, cable guide 53 is formed by causing the parts of supports 31 that touch cable 14 to bend toward the inside of connector 15 with the prescribed radius, avoiding a concentration of bending stress in the specified parts of cable 14.

Figure 10 shows tensile strength testing device 60 which measures the tensile strength in the contact parts of connector 15 and cable 14. With this tensile strength testing device 60, connector 15 is held fast by connector
5 anchoring fixtures 61A and 61B, 10-kgf load 62 is applied to the other end of cable 14 for 1 minute, then it is checked whether there is any abnormality in cable 14 and connector 15.

Figure 11 shows bending strength testing device 70
10 which measures the bending strength in the contact parts of connector 15 and cable 14. With bending strength testing device 70, position P10 is located 300 mm from the contact position of connector 15 and cable 14 is held fast by cable steady brace 71, and 500-gf load 72 is suspended on the
15 other end of cable 14. In this state, bending strength testing device 70 performs bending 20,000 times at the rate of 40 times per minute, where one time means a test in which connector 15 is bent 90 degrees left and right; then one checks for any wire break or other abnormality in cable 14.
20 By performing such testing, one can assess the bending stress of cable 14 that will arise in actual use.

Figure 12 shows the shape of controller main unit 13. Formed on controller main unit 13 are input part 16, which consists of button keys 16A and 16B and cursor keys 16C, and

output unit 17, which consists of lamps. Therefore if the user presses the desired key in input unit 16, controller main unit 13 generates data corresponding to this operation information and outputs it to game machine main unit 11 via cable 14. Conversely, when instruction data for turning the lamps of output unit 17 on or off is sent from game machine main unit 11, controller main unit 13 turns the lamps of output unit 17 on or off in accordance with this instruction data.

Figure 13 shows the internal structure of controller main unit 13 which is a cross-sectional view of the controller main unit 13. Microprocessor 80, which controls controller main unit 13 is connected to input unit 16 (Figure 12) and output unit 17 (Figure 12) and is connected to electrically conductive wires 81A-81E and 1F-1H. Of these, optical fibers 14A-14E are connected to electrically conductive wires 81A-81E via electrical/ optical signal converters 20A-20E, respectively.

Operation information input by the user is supplied from input unit 16 to microprocessor 80. Microprocessor 80 performs the prescribed data processing on the operation information and outputs it to electrical/optical signal converters 20A and 20E via corresponding electrically conductive wires 81A and 81E. Electrical/optical signal

converters 20A and 20E convert the input electrical signals to optical signals and output them to game machine main unit 11 via optical fibers 14A and 14E.

Conversely, feedback information transmitted from game
5 machine main unit 11 via optical fibers 14B, 14C, and 14D are input to electrical/optical signal converters 20B, 20C, and 20D. Electrical/optical signal converters 20B, 20C, and 20D convert the input optical signals to electrical signals and output them to microprocessor 80 via electrically
10 conductive wires 81B, 81C, and 81D, respectively. Based on this feedback information, microprocessor 80 controls the entire controller main unit 13, turning the lamps of output unit 17 on and off.

In controller main unit 13, as in connector 15, optical
15 fibers 14A-14E are arranged so that the bending radius of said optical fibers 14A-14E is greater than the minimum bending radius. Specifically, in controller main unit 13, optical fiber guides 83A-83E are arranged in prescribed positions near optical fibers 14A-14E. Optical fibers 14A-
20 14E are aligned along optical fiber guides 83A-83E, thereby preventing optical fibers 14A-14E from bending with a bending radius smaller than the minimum bending radius. In this way, optical fibers 14A-14E and electrically conductive wires 1F-1H are made to converge into cable 14 and are

accommodated in said cable 14. Cable 14 is attached securely to controller main unit 13 by cable anchoring means 84.

During use, bending stress arises in cable 14 near where it protrudes to the outside from controller main unit 13. Therefore, in controller main unit 13, in the enclosure of controller main unit 13, cable guide 85 is formed by causing the parts that touch cable 14 to bend toward the inside, avoiding a concentration of bending stress in cable 14.

Figure 14 shows tensile strength testing device 90 that measures the tensile strength in the contact parts of controller main unit 13 and cable 14. With this tensile strength testing device 90, as with tensile strength testing device 60 (Figure 14), controller main unit 13 is held fast by controller main unit anchoring means 91A and 91B. A 10-kgf load 92 is applied to the other end of cable 14 for 1 minute. It is then checked to determine if there is any abnormality in cable 14 and controller main unit 13.

Figure 15 shows bending strength testing device 100 that measures the bending strength in the contact parts of controller main unit 13 and cable 14. With bending strength testing device 100, as with bending strength testing device 70 (Figure 11), position P20 located 300 mm from the contact

position of controller main unit 13 and cable 14 is held fast by cable steady brace 101, and load 102 is suspended on the other end of cable 14. In this state, bending strength testing device 100 performs bending 20,000 times at the rate of 40 times per minute, where one time means a test in which controller main unit 13 is bent 90 degrees left and right. One then checks for any wire break or other abnormality in cable 14. By performing such testing, one can assess the bending stress of cable 14 that will arise in actual use.

10 In the above configuration, during sending, controller main unit 13 converts the electrical-signal operation information S1 input from input unit 16 to electrical-signal operation information S2 by electrical/optical signal converter 20 and outputs it to connector 15 via cable 14, 15 which consists of optical fibers. Connector 15 converts the input optical-signal operation information S2 to electrical-signal operation information S3 by electrical/optical signal converter 21 and outputs it to game machine main unit 11. Game machine main unit 11 causes the game to proceed in accordance with this operation information S3.

In response to this, electrical-signal feedback information output from game machine main unit 11 is input to connector 15. Connector 15 converts electrical-signal feedback information S4 to optical-signal feedback

information S5 by electrical/optical signal converter 21 and outputs it to controller main unit 13 via cable 14, which consists of optical fibers. Controller main unit 13 converts optical-signal feedback information S5 to
5 electrical-signal feedback information S6 by electrical/optical signal converter 20, and information in accordance with said feedback information S6 is conveyed to the user via output unit 17.

In this way a connection is made between controller
10 main unit 13 and game machine main unit 11 via optical fibers 14A-14E. During communication, by converting the electrical signals of the transmission object to optical signals and transmitting the optical signals back and forth via optical fibers 14A-14E, no electromagnetic-wave noise is
15 generated, even at high frequency, as happens when electrical signals are transmitted via electrically conductive wires 1A-1E. Thus, there is no need to limit the frequency of the optical signals, that is, the communication speed, and accordingly communication can be done at a higher
20 rate than previously.

Even if optical fibers 14A-14E are made long, the rate of attenuation in the signal level they transmit is much smaller than for electrically conductive wires 1A-1E. Therefore cable 14, which consists of optical fibers 14A-14E,

can be made longer than conventional cable 1 which consists of electrically conductive wires 1A-1E.

Optical fibers 14A-14E of cable 14 are connected to game machine main unit 11 via electrical/optical signal
5 converters 21A-21E of connector 15, and optical signals input from cable 14 are converted to electrical signals by said electrical/optical signal converters 21A-21E and are output to game machine main unit 11, while electrical
signals input from game machine main unit 11 are converted
10 to optical signals and are output to cable 14; in this way, communication is realized using optical fibers 14A-14E in a simple composition, without modifying the composition of game machine main unit 11.

Inside connector 15 and controller main unit 13,
15 optical fiber guides 51A-51G and 83A-83E are arranged in prescribed positions near optical fibers 14A-14E, respectively, and optical fibers 14A-14E are aligned along optical fiber guides 51A-51G and 83A-83E. This makes it possible to prevent optical fibers 14A-14E from bending at a
20 bending radius smaller than the minimum bending radius, and therefore optical signals can be transmitted more accurately than if optical fiber guides 51A-51G and 83A-83E were not provided.

By the above configuration, a connection is made between controller main unit 13 and game machine main unit 11 via cable 14, which consists of optical fibers 14A-14E. During communication, by converting the electrical signals of the transmission object to optical signals and transmitting said optical signals via optical fibers 14A-14E, no electromagnetic-wave noise is generated as happens when electrical signals are transmitted via electrically conductive wires 1A-1E. Thus, to the extent that there is no need, as there was previously, to limit the frequency of the optical signals, that is, the communication speed, the communication rate can be improved.

In the above-described embodiment, five types of data are each transmitted via a corresponding optical fiber 14A-14E. However, this invention is not limited to the features of that embodiment. It will be just as effective as in the above-described case, if two types of data transmitted from controller main unit 13 to game machine main unit 11 are composed and this composite data is transmitted by one optical fiber, while three types of data transmitted from game machine main unit 11 to controller main unit 13 are composed and this composite data is transmitted by one optical fiber.

This is specifically explained below using Figure 16 through Figure 18. Figure 16 is a cross-sectional view of cable 110 according to a further embodiment. Cable 110 has optical fibers 110A and 110B for transmitting optical
5 signals and electrically conductive wires 110C-110E for transmitting electrical signals, and these are arranged so as to be adjacent to each other.

Optical fiber 110A is made so that it transmits a composite signal generated by combining data TxD,
10 communication standard clock SCK, and communication enable signal DTR, which are transmitted from game machine main unit 11 to controller main unit 13. Optical fiber 110B is made so that it transmits a composite signal generated by combining data RxD and communication completion signal
15 DSR, which are transmitted from controller main unit 13 to game machine main unit 11.

Electrically conductive wire 110C is an electrically conductive wire for an 8-V power source, and electrically conductive wire 110D is an electrically conductive wire for
20 power source Vcc. In cable 110, the periphery of optical fibers 110A and 110B and electrically conductive wires 110C and 110D is covered with electrically conductive wire 110E for grounding line GND, and its periphery in turn is covered with vinyl cover 11, which is an insulating substance. By

thus reducing the number of optical fibers 110A and 110B housed in cable 110, cable 110 can be made thinner.

Next, the internal structure of connector 120 is described using Figure 17, which is a cross-sectional view of said connector 120. Signal pin 121A transmits data TxD from game machine main unit 11 to controller main unit 13. Signal pin 121B transmits communication standard clock SCK from game machine main unit 11 to controller main unit 13, and signal pin 121C transmits communication enable signal DTR from game machine main unit 11 to controller main unit 13.

Signal pin 121D transmits data RxD from controller main unit 13 to game machine main unit 11. Signal pin 121E transmits communication completion signal DSR from controller main unit 13 to game machine main unit 11. Signal pin 121F carries the current of an 8-V power source. Signal pin 121G carries the current of power source Vcc, and signal pin 121H is for the grounding line GND.

Signal pin 121A is connected to electrical/optical signal conversion synthesizer 123A via electrically conductive wire 122A. Signal pin 121B is connected to electrical/optical signal conversion synthesizer 123A via electrically conductive wire 122B. Signal pin 121C is connected to electrical/optical signal conversion

synthesizer 123A via electrically conductive wire 122C.

Signal pin 121D is connected to electrical/optical signal separation converter 123B via electrically conductive wire 122D, and signal pin 121E is connected to electrical/

5 optical signal separation converter 123E via electrically conductive wire 122E. Signal pins 121F-121H are directly connected to the corresponding electrically conductive wires 110C-110E.

Electrical/optical signal conversion synthesizer 123A
10 is connected to optical fiber 110A. It allocates light of a different wavelength to data TxD, which is input from game machine main unit 11 via signal pin 121A and electrically conductive wire 122A, communication standard clock SCK, which is input via signal pin 121B and electrically
15 conductive wire 122B, and communication enable signal DTR, which is input via signal pin 121C and electrically conductive wire 122C. By converting them to optical signals and combining them, it generates a composite signal, and it outputs the composite signal
20 to optical fiber 110A.

Electrical/optical signal separation converter 123B is connected to optical fiber 110B. After it separates the composite signal input from optical fiber 110B into optical

signals of two wavelengths by, for example, passing it through a prism or other spectroscopy, it converts them respectively to two electrical signals, and of these, it outputs data RxD to game machine main unit 11 via

5 electrically conductive wire 122D and signal pin 121D, and it outputs communication completion signal DSR to game machine main unit 11 via electrically conductive wire 122E and signal pin 121E.

The internal structure of controller main unit 130 is shown in Figure 18, which is a cross-sectional view of said controller main unit 130. Microprocessor 131, which controls controller main unit 130, is connected to electrically conductive wires 132A-132E and 110C-110E. Of these, electrically conductive wires 132A-132C are connected to optical fiber 110A via electrical/optical signal separation converter 133A, while electrically conductive wires 132D and 132E are connected to optical fiber 110B via electrical/optical signal conversion synthesizer 133B.

Electrical/optical signal separation converter 133A separates the composite signal input from game machine main unit 11 via optical fiber 110A into optical signals of three wavelengths by passing it through a spectroscopy. It then converts each of them to an electrical signal, and outputs the thus obtained data TxD, communication standard clock SCK,

and communication enable signal DTR to microprocessor 131 via corresponding electrically conductive wires 132A-132C.

Electrical/optical signal conversion synthesizer 133B allocates light of a different wavelength to data RXD and
5 communication completion signal DSR supplied from microprocessor 131 via electrically conductive wires 132D and 132E. After converting them to optical signals, it combines them to generate a composite signal, and it outputs said composite signal to optical fiber 110B.

10 In the above-described embodiment, the invention is applied to game controller 12 for operating game machine main unit 11. However, as in the above-described case, if this invention is applied to an external operation device that operates various other types of operation objects, such
15 as, for example, external operation devices for operating a computer, it will be just as effective.

As described above, with this invention, the operation means is connected to the operation object via optical fiber, and by converting electrical signals of the transmission
20 object to optical signals during communication and transmitting the optical signals via an optical fiber, even if the frequency of the optical signals is high, no electromagnetic-wave noise is generated as happens when the operation means is connected via electrically conductive

wires, so there is no need to limit the frequency, that is, the communication speed, and thus communication can be done at a higher rate than previously.

**CLAIMS****WHAT IS CLAIMED IS:**

1. An external operation device connected to an
5 operation object and by which the operation object is
operated which comprises:

an external operation device having an operation
means that converts electrical signals of a transmission
object input to optical signals in accordance with operation
10 by the user by an internal electro-optical signal converter
and outputs said optical signals to said operation object,
and converts optical signals transmitted from said operation
object to electrical signals by said electro-optical signal
converter and outputs to the outside information in
15 accordance with said electrical signals,

an optical fiber, one end of which is attached to
said operation means that transmits optical signals between
said operation means and said operation object, and

a connection means provided on the other end of
20 said optical fiber that is detachably connected to said
operation object that converts optical signals transmitted
from said operation means via said optical fiber to
electrical signals by an internal electro-optical signal
converter and outputs said electrical signals to said



operation object, and converts electrical signals supplied from said operation object to optical signals by said electro-optical signal converter and outputs said optical signals to said operation means.

5

2. An external operation device according to claim 1 wherein

said operation means and said connection means have optical fiber guides in prescribed positions near said optical fiber, the bending radius of said optical fiber being greater than the minimum bending radius, and said optical fiber is made to lie along said optical fiber guides.

3. An external operation device according to claim 1 wherein said operation object is a game machine.

4. An entertainment system having a game machine main unit, a game controller, and cable data transmission means between said game machine main unit and said game controller, said cable data transmission means comprising:

an optical cable and an electrically conductive cable wherein signals that can be a source of electromagnetic-wave noise are transmitted via said optical cable and signals that cannot be a source of



electromagnetic-wave noise are transmitted via said electrically conductive cable.

5 5. An entertainment system according to claim 4 wherein said signals that can be a source of electromagnetic-wave noise consist of high-frequency alternating current, and

 said signals that cannot be a source of electromagnetic-wave noise consist of direct current.

10

6. An entertainment system according to claim 4 wherein said signals that can be a source of electromagnetic-wave noise consist of power-source current or ground current.

15

7. An entertainment system according to claim 4 wherein said cable is connected to said game machine main unit or said game controller via a connector, and

 an optical fiber guide is arranged within the
20 housing of said connector along multiple optical fibers that constitute said optical cable, the bending radius of said optical fiber being restricted to be at least as large as a prescribed value.



8. An entertainment system according to claim 4 wherein said cable is connected to said game machine main unit or said game controller via a connector,

5 said connector having an electrical/optical signal conversion synthesizer which converts multiple data signals into a single composite optical signal, and it is output to one optical fiber.

9. An entertainment system according to claim 8
10 wherein said electrical/optical signal conversion synthesizer converts to an optical signal by allocating light of a different wavelength to each different data signal, and generates a composite optical signal by putting these optical signals together.

15

10. An entertainment system according to claim 4 wherein said cable is connected to said game machine main unit or said game controller via a connector, and

20 said connector has an electrical/optical signal separation converter, and the composite optical signal composed of multiple data signals is converted to the original multiple data signals by said electrical/optical signal separation converter and is output.



11. An entertainment system according to claim 10
wherein said electrical/optical signal separation converter
has a spectroscope, the composite optical signal that is
input is separated into optical signals of different
5 wavelengths, and the separated optical signals are converted
into electrical signals to generate the original data
signals.

12. An entertainment system according to claim 4
10 wherein said cable is connected to said game machine main
unit or said game controller via a connector, and
a means to avoid a concentration of bending stress
is provided where said connector and said cable are
connected.

15

13. An entertainment system according to claim 12
wherein said means to avoid a concentration of bending
stress causes the housing of said connector to curve inward
at a prescribed radius at the part that comes into contact
20 with said cable.