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PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 1 of 2

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. _____

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Additional inventors are being named on the _____ separately numbered sheets attached hereto.

TITLE OF THE INVENTION (500 characters max):

Optical Signal Transfer System

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ENCLOSED APPLICATION PARTS (check all that apply)

☐ Application Data Sheet. See 37 CFR 1.76	☐ CD(s). Number of CDs _____
☒ Drawing(s) Number of Sheets <u>4</u>	☐ Other (specify) _____
☒ Specification (e.g. description of the invention) Number of Pages <u>12</u>	

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Optical Signal Transfer System

Field of the Invention

The present invention relates to optical signalling for control purposes, particularly, but not exclusively, for controlling power supply in inductive couplings.

5 Background

When providing power to electric devices it is often desirable to provide a channel for signal transfer. Such a signal transfer channel may be useful for power regulation, for example. Thus a communication channel is often provided alongside the power input channel. Known methods for providing such a communication
10 channel include wired connections to the device, which may be packaged within the same cable as the power lines.

Devices such as transformers and induction connectors transfer energy between primary and secondary coils by induction. In order to regulate the characteristics of the power provided to the secondary coil such as voltage, current,
15 temperature and the like, feedback from the device to the power source is desirable. However in applications where the primary coil and secondary coil must remain galvanically isolated from one another a wired connection is inherently unsuitable.

Systems for the transfer of signals between galvanically isolated elements of a circuit are known. For example, optocouplers are used to convert an electrical signal
20 into an optical signal which is transmitted from an optical transmitter, such as a light emitting diode, over a short optical path to a galvanically isolated receiver, such as a photo-transistor which converts the signal back into an electrical current.

Because optocouplers generally transmit low power signals over very short and unobstructed distances, the signal to noise ratio is typically very high. Thus
25 analog signals may be used with negligible loss of signal clarity. However optocouplers require a line-of-sight between the transmitter and receiver and are inappropriate for systems where alignment is problematic.

Inductive power outlets allow power to be transferred between a primary coil wired to a power supply and a secondary coil wired to an electric load. In some
30 inductive power outlets the primary coil is concealed behind a surface layer, but to allow power transfer, the secondary coil in front of the surface layer is required to be

brought into alignment with the primary coil. Standard optocouplers are unsuitable for transmitting signals in such a configuration because the optical path between the coils is obstructed by the surface layer.

5 There is therefore a need for a system for transferring an optical signal between the coils of an inductive energy coupling across an intermediate surface and the present invention addresses this need.

Summary of the Invention

It is therefore an aim of the present invention to provide a signal transfer system for regulating power transfer between a primary coil behind a surface layer and a secondary coil brought into alignment with the primary coil; said signal transfer system comprising at least one optical transmitter in front of a surface layer for transmitting electromagnetic radiation of a type and intensity capable of penetrating said surface layer and being received by at least one optical receiver behind said surface layer.

Typically, said optical transmitter comprises an infra red emitting diode .
10 Preferably the optical receiver is selected from the group comprising: phototransistors, photodiodes and light dependent resistors.

In preferred embodiments the surface layer is constructed from a material selected from the group comprising glass, plastic, mica, formica, wood, wood veneer, canvas, cardboard, stone, linoleum and paper. Optionally, the surface layer
15 comprising a generally opaque panel punctuated by at least one optical path for guiding said optical signal to said optical receiver. Typically, the optical path is selected from the group comprising: waveguides, optical fibers and windows.

The optical signal may carry encoded data pertaining to at least one of the group comprising:

- 20 ▪ presence of an electric load;
- required operating voltage for said electric load;
- required operating current for said electric load;
- required operating temperature for said electric load;
- measured operating voltage for said electric load;
- 25 ▪ measured operating current for said electric load;
- measured operating temperature for said electric load, and
- a user identification code.

Optionally, the inductive energy couple is a device selected from the group comprising: a transformer, a DC-to-DC converter, an AC-to-DC converter, an AC-to-
30 AC converter, a flyback transformer, a flyback converter, a full-bridge converter, a

half-bridge converter and a forward converter. Typically, the primary coil is galvanically isolated from said secondary coil.

A further aim of the invention is to provide a method for regulating power transfer across an inductive coupling comprising a primary coil behind a surface layer
5 and a secondary coil in front of said surface layer, said method comprising the following steps:

- a. providing at least one optical transmitter in front of said surface layer;
- b. providing at least one optical receiver behind the surface layer;
- c. communicating a regulating signal to said optical transmitter;
- 10 d. said optical transmitter transmitting said regulating signal as electromagnetic radiation of a type and intensity capable of penetrating said surface layer;
- e. receiving said electromagnetic radiation by said optical receiver; and
- f. adjusting said power transfer according to said regulation signal.

Optionally, the regulation signal carries details of power requirements of said
15 load. Typically, the method regulates power transfer across an inductive coupling wherein said optical signal is provided by monitoring at least one operating parameter of said electric load and encoding the monitored parameter data into said optical signal. Alternatively or additionally, the method regulates power transfer across an inductive coupling wherein said optical signal carries data pertaining to at least one
20 parameter selected from the group comprising operating voltage, operating current and operating temperature. Preferably, the method comprises the preliminary step of detecting the presence of an electric load.

Brief Description of the Figures

For a better understanding of the invention and to show how it may be carried into effect, reference will now be made, purely by way of example, to the accompanying drawings.

5 With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no
10 attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention; the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice. In the accompanying drawings:

 Fig. 1 is a schematic diagram showing an inductive power outlet transferring
15 power to a laptop computer resting on a work surface, wherein power transfer is regulated by an optical signal passing through a translucent layer of the work surface according to a first embodiment of the present invention;

 Fig. 2 is a schematic diagram showing an inductive power outlet transferring
20 power to a laptop computer, wherein power transfer is regulated by an optical signal passing through an optical window within the surface layer according to a second embodiment of the present invention;

 Fig. 3 is a flowchart representing a method for regulating power transfer across an inductive coupling according to a third embodiment of the invention, and

 Fig. 4 is a block diagram of a system for regulating inductive power transfer
25 using a digital optical signal according to a fourth embodiment of the inventions.

Description of the Preferred Embodiments

Reference is now made to Fig. 1 which shows an inductive power outlet consisting of a primary unit 100 behind a surface layer 300, configured to transfer
30 power to a secondary unit 200 in front of the surface layer 300.

A primary coil 120 in the primary unit 100 is wired to a power supply 140 via a driver 160 which provides the electronics necessary to drive a primary coil 120. Driving electronics may include a switching unit providing a high frequency oscillating voltage supply, for example. A secondary coil 220 in the secondary unit
5 200 is wired to an electric load, such as a computer 240, for example, and is configured to inductively couple with the primary inductive coil 120.

The primary unit 100 may be concealed behind or within a vertical surface such as a wall of a building or a cabinet for example, behind an outer payer such as wallpaper or stretched canvas for example. Alternatively the primary coil 120 may be
10 concealed behind a facing layer of a horizontal platform on a desk-top, a kitchen work-top, a conference table or a work bench, for example fabricated from glass, plastic, Formica or wood veneer. In other embodiments a primary coil 120 is concealed beneath flooring such as rugs, fitted carpet, parquet, linoleum, floor tiles, tiling, paving and the like.

15 As shown in Fig. 1, a system 380 is provided for transferring an optical signal through the surface layer 300 according to a first embodiment of the present invention.

An optical transmitter 280, such as a light emitting diode (LED) for example, is incorporated within the secondary unit 200 and is configured and operable to
20 transmit electromagnetic radiation of a type and intensity capable of penetrating the casing 202 of the secondary unit, and the surface layer 300. An optical receiver 180, such as a photodiode, a phototransistor, a light dependent resistors of the like, is incorporated within the primary unit 100 for receiving the electromagnetic radiation transmitted through the surface layer 300. Although the optical transmitter 280 and
25 optical receiver 180 are described herein laterally displaced from the primary coil 120 and secondary coil 220, in preferred embodiments the optical transmitter 280 is located at the center of the secondary coil 220 and the optical receiver 180 is located at the center of the primary coil 120. This permits alignment to be maintained through 360 degree rotation of the secondary unit 200.

30 It is noted that many materials are partially translucent to infra-red light. It has been found that relatively low intensity infra red signals from LEDs and the like, penetrate several hundred microns of common materials such as plastic, cardboard,

Formica or paper sheet, to a sufficient degree that an optical receiver 180, such as a photodiode, a phototransistor, a light dependent resistors of the like, behind a sheet of from 0.1 mm to 2 mm of such materials, can receive and process the signal. For example a signal from an Avago HSDL-4420 LED transmitting at 850nm over 24
5 degrees, may be detected by an Everlight PD15-22C-TR8 NPN photodiode, from behind a 0.8 mm Formica sheet. For signalling purposes, a high degree of attenuation may be tolerated, and penetration of only a small fraction, say 0.1% of the transmitted signal intensity may be sufficient. Thus an infra-red signal may be used to provide a communication channel between primary and secondary units galvanically isolated
10 from each other by a few hundred microns of wood, plastic, Formica, wood veneer, glass or the like. Such a signal may be useful in various inductive energy couples such as transformers, DC-to-DC converters, AC-to-DC converters, AC-to-AC converters, flyback transformers, flyback converters, full-bridge converters, half-bridge converters and forward converters.

15 In inductive couples, the communication channel may be used to transfer data between the primary and the secondary coils. The data transferred may be used to regulate the power transfer, for example. Typically the signal carries encoded data pertaining to one or more items of the list below:

- the presence of the electric load;
- 20 ▪ the required operating voltage for the electric load;
- the required operating current for the electric load;
- the required operating temperature for the electric load;
- the measured operating voltage for the electric load;
- the measured operating current for the electric load;
- 25 ▪ the measured operating temperature for the electric load, or
- a user identification code.

Reference is now made to Fig. 2, which schematically shows an inductive power outlet incorporating a signal transfer system 2380, according to a second embodiment of the present invention. Where the intermediate surface layer 2300 is
30 opaque to infra-red, particularly where the intermediate surface layer 2300 is relatively thick, an optical path 2340 may be provided to guide the signal to the

optical receiver 2180. Typically, the optical path 2340 is a waveguide such as an optical fiber, alternatively, the optical receiver 280 may be placed behind an opening 2360 in the face 2320 of the surface and covered with a translucent window 2362.

Fig. 3 is a flowchart showing a method for transferring an optical signal between a primary unit and a secondary unit via an intermediate layer. The method comprises the following steps: an optical transmitter is incorporated within the secondary unit – step (a); an optical receiver is incorporated within the primary unit – step (b); the optical transmitter transmits electromagnetic radiation of a type and intensity capable of penetrating the surface layer – step (c); and the optical receiver receives the electromagnetic radiation – step (d).

It will be appreciated that such a method may be applicable to transmitting a regulation signal for regulating power transfer across an inductive coupling by monitoring at least one operating parameter of said electric load and encoding the monitored parameter data into said optical signal. Similarly, data relating to the presence of an electric load, its power requirements, operating voltage, operating current, operating temperature or the like may be communicated.

A further system for regulating inductive power transfer according to a fourth embodiment of the inventions is shown in the block diagram of Fig. 4. An inductive power outlet 4100 is configured to couple with a secondary unit 4200 separated therefrom by a surface layer 4300, such that power is transferred to an electric load 4240.

The inductive power outlet 4100 of the fourth embodiment includes a primary inductive coil 4120, a half-bridge driver 4102, a multiplexer 4104, a primary microcontroller 4106, a tone detector 4108 and an optical receiver 4180. The secondary unit 4200 consists of a secondary coil 4220, a receiver 4202, a secondary microcontroller 4204, an optical transmitter 4280 and a load connecting switch 4206.

The primary inductive coil 4120, of the inductive power outlet 4100, is driven by the half-bridge driver 4102 which receives a driving signal S_D from the multiplexer 4104. The multiplexer 4104 selects between an initialization signal S_I or a modulation signal S_M . The initialization signal S_I provides a detection means for activating the inductive power outlet 4100 when a secondary unit 4200 is present. Once active, the

modulation signal S_M provides a means for regulating power transfer from the power outlet 4100 to the secondary unit 4200.

Secondary unit detection is provided by the primary microcontroller 4106 intermittently sending an initialization signal S_I to the multiplexer 4104 when the power outlet 4100 is inactive. The multiplexer 4104 relays the initialization signal S_I to the half-bridge driver 4102, which results in a low powered detection pulse being transmitted by the primary coil 4120. If a secondary unit 4200 is aligned with the inductive power outlet 4100, the low powered detection pulse is inductively transferred to the secondary coil 4220 across the surface layer 4300. The receiver 4202 is configured to receive this detection pulse and relay a detection signal to the secondary microcontroller 4204 which sends a signal to the load connector switch 4206 to connect the load and triggers the optical transmitter 4280 to transmit an optical signal through the surface layer 4300 confirming that the secondary unit is in place. The optical signal is received by the optical receiver 4180 in the power outlet 4100, and is then relayed to the tone detector 4108 which sends a confirmation signal to the primary microcontroller 4106. The primary microcontroller 4106 then activates the power outlet 4100 by triggering the multiplexer 4104 to select the modulation signal S_M to regulate the power transfer.

The modulation signal S_M comes directly from the optical receiver 4180 and is used to regulate the duty cycle of the half-bridge driver 4102. Power transferred to the secondary unit 4200 is monitored by the secondary microcontroller 4202 which generates a modulation signal S_M which is relayed to the optical transmitter 4280, which transmits a digital optical signal. The modulation signal S_M is thus received by the optical detector 4180 of the primary unit 4180, relayed to the multiplexer 4104 and used to regulate the half-bridge driver 4102.

The basic signal feedback system and method described hereinabove are capable of much variation. Thus the scope of the present invention is defined by the appended claims and includes both combinations and sub combinations of the various features described hereinabove as well as variations and modifications thereof, which would occur to persons skilled in the art upon reading the foregoing description.

In the claims, the word "comprise", and variations thereof such as "comprises", "comprising" and the like indicate that the components listed are included, but not generally to the exclusion of other components.

Claims

1. A signal transfer system for regulating power transfer across an inductive coupling, said signal transfer system comprising at least one optical transmitter in front of a surface layer for transmitting electromagnetic radiation of a type and intensity capable of penetrating said surface layer and being received by at least one optical receiver behind the surface layer.
5
2. The system of claim 1 wherein said optical transmitter comprises a light emitting diode.
3. The system of claim 1 wherein said optical transmitter transmits an infra red signal.
10
4. The system of claim 1 wherein said optical receiver is selected from the group comprising: phototransistors, photodiodes and light dependent resistors.
5. The system of claim 1 wherein said surface layer is constructed from a material selected from the group comprising glass, plastic mica, formica, wood, wood veneer, canvas, cardboard, stone, linoleum and paper.
15
6. The system of claim 1 wherein said surface layer comprises a generally opaque panel punctuated by at least one optical path for guiding said optical signal to said optical receiver.
7. The system of claim 6 wherein said optical path is selected from the group comprising: waveguides, optical fibers and windows.
20
8. The system of claim 1 wherein said inductive couple comprises:
 - a. a primary coil behind the outer face of said surface layer for connecting to a power source; and
 - b. a secondary coil in front of said surface layer for connecting to an electric load.
25
9. The system of claim 8 said optical signal carrying encoded data pertaining to at least one of the group comprising:
 - a. presence of the electric load;
 - b. required operating voltage for said electric load;

- c. required operating current for said electric load;
 - d. required operating temperature for said electric load;
 - e. measured operating voltage for said electric load;
 - f. measured operating current for said electric load;
 - 5 g. measured operating temperature for said electric load, and
 - h. a user identification code.
10. The system of Claim 8, said inductive energy couple being a device selected from the group comprising: a transformer, a DC-to-DC converter, an AC-to-DC converter, an AC-to-AC converter, a flyback transformer, a flyback converter, a
- 10 full-bridge converter, a half-bridge converter and a forward converter.
11. The system of Claim 8, said primary coil being galvanically isolated from said secondary coil.
12. A secondary unit for inductively coupling to a primary unit via an intermediate layer, said secondary coil comprising an inductive coil and an optical transmitter
- 15 for alignment purposes.
13. Use of an optical transmitter for aligning a mobile secondary coil with a concealed primary coil having an optical receiver associated therewith.
14. Use of an optical transmitter for providing feedback from a mobile secondary coil to a concealed primary coil having an optical receiver associated therewith.
- 20 15. A method for regulating power transfer across an inductive coupling, said inductive coupling comprising a primary coil behind a surface layer and a secondary coil in front of said surface layer, said method comprising the following steps:
- a. providing at least one optical transmitter in front of said surface layer;
 - 25 b. providing at least one optical receiver behind the outer face of said surface layer;
 - c. communicating a regulation signal to said optical transmitter;

- d. transmitting said regulation signal from said optical transmitter as electromagnetic radiation of a type and intensity capable of penetrating said surface layer;
- e. receiving said electromagnetic radiation by said optical receiver; and
- 5 f. adjusting said power transfer according to said regulation signal.

- 16. The method of Claim 14 for regulating power transfer across an inductive coupling wherein said regulation signal carries details of power requirements of said load.
- 17. The method of Claim 14 for regulating power transfer across an inductive
10 coupling wherein said optical signal is provided by monitoring at least one operating parameter of said electric load and encoding the monitored parameter data into said optical signal.
- 18. The method of Claim 14 for regulating power transfer across an inductive
15 coupling wherein said optical signal carries data pertaining to at least one parameter selected from the group comprising operating voltage, operating current and operating temperature.
- 19. The method of Claim 14 for regulating power transfer across an inductive coupling comprising the preliminary step of detecting the presence of an electric
20 load.

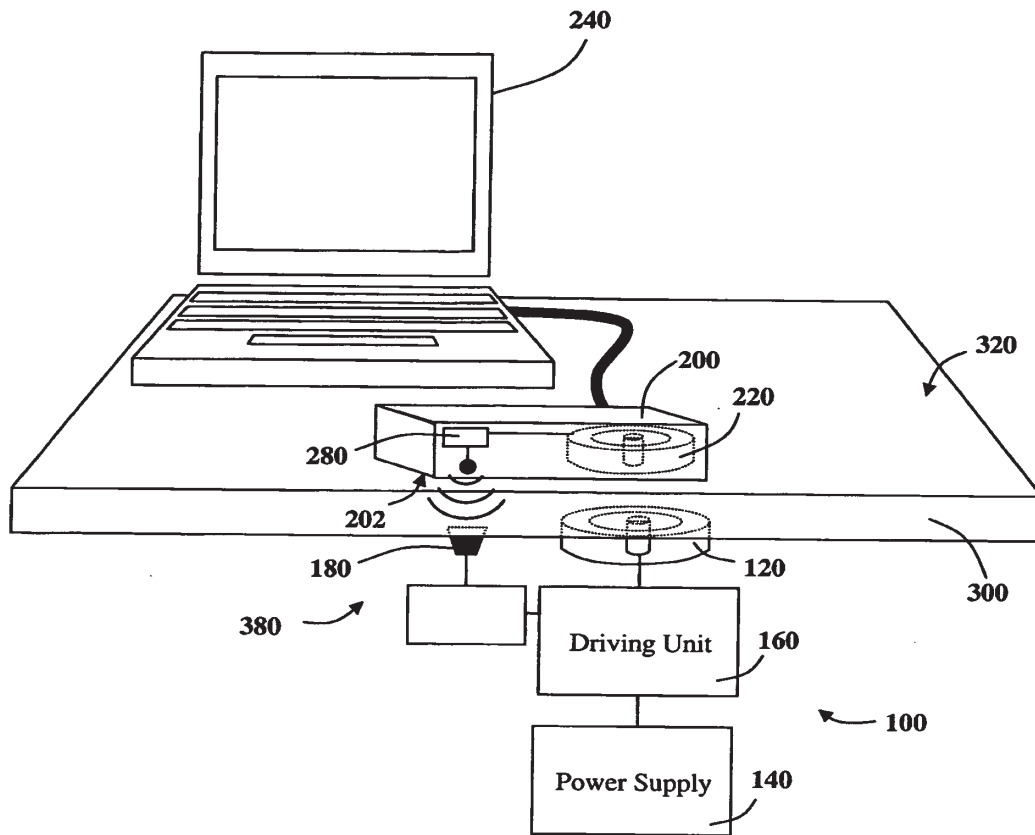


Fig. 1

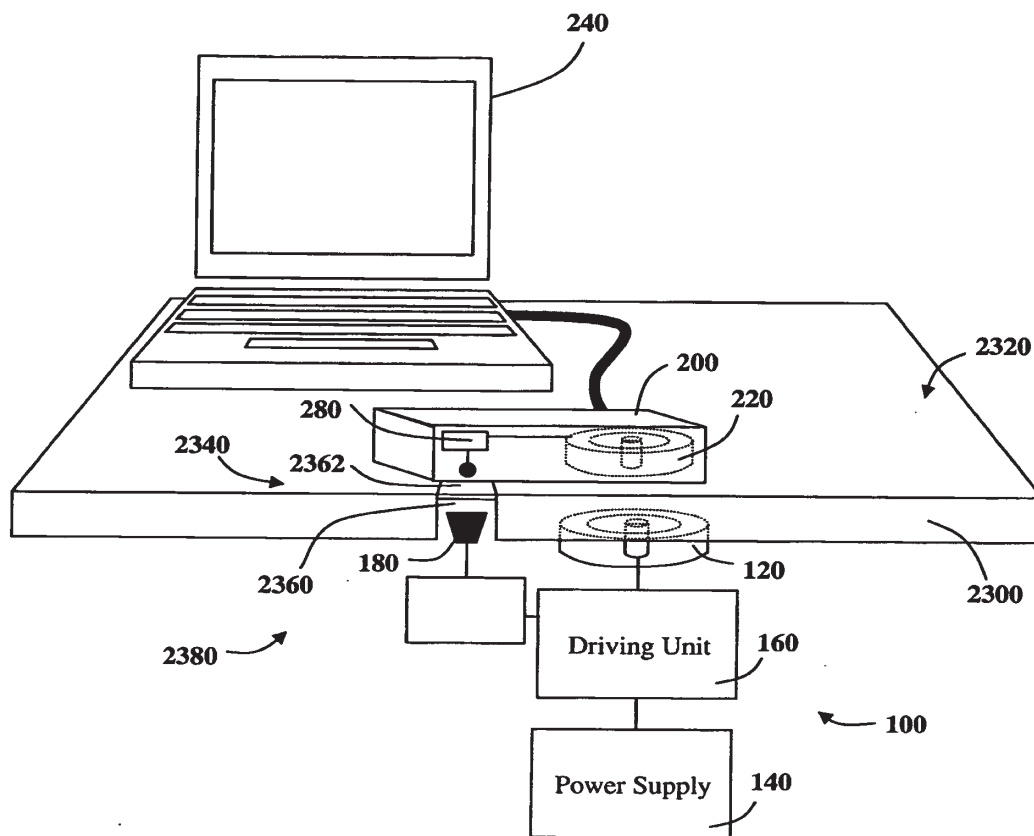


Fig. 2

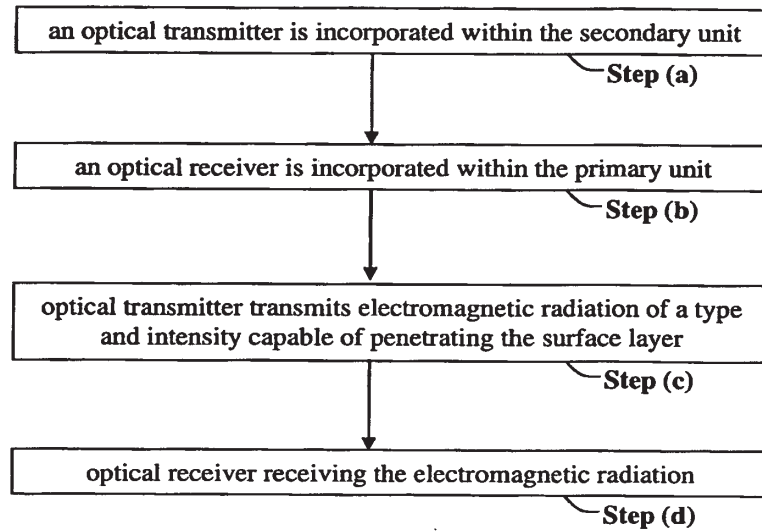


Fig. 3

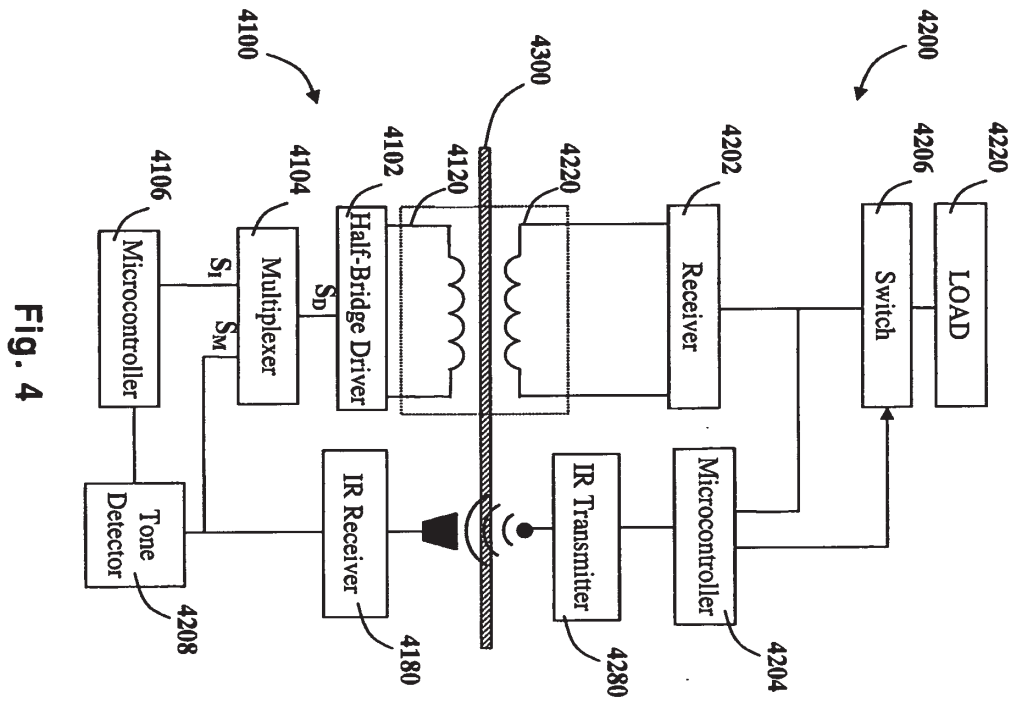


Fig. 4