



Title of the Invention: RADIO UNIT AND ELECTRONIC APPARATUS  
USING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

5           This application is based upon and claims the benefit of priority  
from the prior Japanese Patent Application No. 2004-168648, filed on June  
7, 2004, and the entire contents of which are incorporated herein by  
reference.

10   BACKGROUND OF THE INVENTION

Filed of the Invention

          The present invention relates to radio units that send/receive  
information to/from external communications devices, and electronic  
apparatus including the radio units.

15

Description of the Related Art

          Recently, data carrier systems or Radio Frequency Identification  
(RF-ID) systems (ISO/IEC 14443) have been proposed which write/read  
data to/from a non-contact radio unit using electromagnetic induction  
20   waves without using a reader/writer directly. In addition, wristwatches  
with such radio units have been developed.

          In these wristwatches, the radio unit comprises a ring-like antenna  
that fits coaxially over the upper outer periphery of the watchcase in order  
25   to ensure a long communication distance between the wristwatch and the  
RF-ID system.



In manufacture, however, in such arrangement the radio unit cannot be easily connected to a circuit board provided within the watchcase. In addition, an IC chip that stores various information to be sent/received to/from the reader/writer can be easily removed out from the radio unit.

5 Thus, there is a possibility that the information stored in the IC chip can be acquired illegally. Since the radio unit is disposed within the watchcase, the sensitivity of the radio unit to radio waves is reduced. Thus, it is difficult to ensure a sufficient communication distance between the wristwatch and a communications device included in the RF-ID system.

10

## SUMMARY OF THE INVENTION

In the present invention, a radio unit is disposed such that its antenna is positioned near and within an open end of a case of an electronic apparatus. A lead of the radio unit is bent in accordance with  
15 an inner configuration of the case such that a circuit board is disposed at a deeper position within the case.

Thus, according to the radio unit and an electronic apparatus using the radio unit, a sufficiently long communication distance is ensured  
20 between the radio unit and the external communications device. In addition, illegal acquirement of the information stored in an integrated circuit of the radio unit by the third party is prevented. Furthermore, in manufacture the radio unit can be easily connected to the circuit board.

## 25 BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred

embodiments of the present invention and, together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the present invention in which:

5

FIG. 1 is a plan view of a wristwatch illustrating an electronic apparatus as an embodiment 1 of the present invention;

FIG. 2 is a block diagram of the wristwatch of FIG. 1 and a gate device;

10 FIG. 3 is an enlarged cross-sectional view of an essential portion of the wristwatch taken along a line III-III of FIG. 1;

FIG. 4A is a plan view of a radio unit of the FIG. 1 wristwatch;

FIG. 4B is a bottom view of the radio unit of the FIG. 4A;

15 FIG. 5 is a plan view of a wristwatch illustrating an electronic apparatus as an embodiment 2 of the present invention;

FIG. 6 is an enlarged cross-sectional view of an essential portion of the wristwatch taken along a line VI-VI of FIG. 5;

FIG. 7A is a plan view of a radio unit of the FIG. 5 wristwatch;

FIG. 7B is a bottom view of the radio unit of FIG. 5;

20 FIG. 8 is a plan view of a wristwatch as a modification 1;

FIG. 9 is an enlarged cross-sectional view of an essential portion of the wristwatch taken along a line IX-IX of FIG. 8;

FIG. 10 an enlarged cross-sectional view of an essential portion of a wristwatch as a modification 2;

25 FIG. 11 an enlarged cross-sectional view of an essential portion of a wristwatch as a modification 3;

FIG. 12 is a perspective view of a radio unit included in the FIG. 11

wristwatch;

FIG. 13 is an enlarged view of an essential portion of the bottom of the wristwatch; and

FIG. 14 is a bottom view of the whole wristwatch.

5

## DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will be described with reference to the accompanying drawings.

### 10 <Embodiment 1>

FIG. 1 is a plan view of a wristwatch illustrating an electronic apparatus 100 as an embodiment 1 of the present invention. In wristwatches 100, 300 and 400 of FIGS. 1, 5 and 8 illustrating electronic apparatus of the present invention, frame parts 14, 314 and 414 of radio units 1, 301 and 401, respectively, are schematically illustrated hatched. A bezel 7 of each of the wristwatches 100, 300 and 400 is cut at 12 and 16 o'clock.

The wristwatch 100 comprises a radio unit 1 that in turn comprises part of an automatic ticket examination system that employs, for example, an RF-ID system that send/receives various information to/from a gate device 200 (FIG. 2) as an external communications device.

Now, the composition of the wristwatch 100 and the gate device 200 will be described with reference to the block diagram of FIG. 2.

First, the wristwatch 100 will be described with respect to FIG. 2.

In the wristwatch 100, a time counter 2 is connected electrically to the radio unit 1.

The time counter 2 is implemented, for example, on a circuit board 3, and comprises a timepiece control 21, an oscillator 22 that generates clock signals of a predetermined frequency and outputs them to the timepiece control 21, an input unit 23 that is responsive to operation of a switch 51 by a user to output an operation signal to the timepiece control 21, a display output 24 that outputs display data to a liquid crystal display 42 to be described later in more detail, a notification output 25 that outputs a voice signal, for example, to a speaker (not shown), and a memory 26 that comprises an EEPROM, for example.

The radio unit 1 comprises, for example, an RF-ID transponder that comprises part of a RF-ID system of either an electromagnetic induction type or an electromagnetic coupling type. As shown in FIG. 2, in the radio unit 1 a capacitor 12 is connected across both ends of an antenna 11. An IC chip 13 of an integrated circuit, which is connected to the capacitor 12, comprises an AC/DC converter 13a, a clock reproduction unit 13b, a demodulator 13c, a decoder 13d, a memory 13e, an encoder 13f, a modulator 13g, a power source control 13h, and a data carrier control 13i.

An alternating current generated on the antenna 11 is rectified by the AC/DC converter 13a to a direct current, which is then given via the power source control 13h to the data carrier control 13i as power that drives the radio unit 1. A clock signal reproduced by the clock reproduction unit 13b and data that is demodulated by the demodulator

13c and then decoded by the decoder 13d, based on the alternating current generated on the antenna 11, are inputted to the data carrier control 13i.

5 The data carrier control 13i reads data decoded by the decoder 13d in synchronization with the clock signal, and then stores it, for example, in the memory 13e. The data carrier control 13i also delivers the data stored in the memory 13e to the encoder 13f based on the read data. The data encoded by the encoder 13f is modulated by the modulator 13g and then sent to the antenna 11.

10

When the user passes through the gate 200, the antenna 11 is caused to face a reader/writer antenna 201 of the gate 200. At this time, the radio unit 1 sends/receives various information on the user's passage through the gate 200 to/from a reader/writer 202 of the gate device 200, 15 using an induction electromagnetic field produced between the antennas 11 and 201.

The memory 13e is, for example, composed of an EEPROM, which stores or has stored data involved in the identification of the user to be sent 20 to the reader/writer 202 via the antenna 11 when the user passes through the gate, and various data involved in the fare adjustment processes performed for the user, the user's passage date and a history of such processes and dates in the past received via the antenna 11 from the reader/writer 202.

25

Then, the composition of the gate device 200 will be described. The gate device 200 is a component of the RF-ID system. As shown in FIG.

2, the gate device 200 comprises the reader/writer antenna 201, a reader/writer 202 that is connected to a non-grounding terminal of the antenna 201 thereof, a controller/system 203 connected to the reader/writer 202, and a gate opening/closing device 204 connected to the  
5 controller/system 203.

The reader/writer 202 performs an encoding process and a demodulating process on control signals outputted from the controller/system 203. The reader/writer 202 then drives the  
10 reader/writer antenna 201 based on the processed control signals and clock signals of a predetermined frequency outputted from an oscillator (not shown). The reader/writer 202 also reads/writes various information sent/received to/from the radio unit 1 via the reader/writer antenna 201.

15 When the user passes through the gate 200, the reader/writer antenna 201 sends/receives various information involving the user's passage through the gate to/from the radio unit antenna 11, using an induction electromagnetic field formed between the antennas 201 and 11.

20 The controller/system 203 controls the opening/closing of the gate 200 by the gate opening/closing device 204 based on the various information sent/received between the reader/writer 202 and the radio unit 1.

25 Communication to be performed between the gate 200 and the wristwatch 100 when the user wearing the wristwatch 100 passes through the gate will be described next.

When the user passes through the gate 200, the user brings the wristwatch 100 close to the reader/writer antenna 201 of the gate device 200 such that the radio unit antenna 11 faces the reader/writer antenna 201 so as to establish an induced electromagnetic field between the antennas 201 and 11. Thereupon, various information involved in the user's passage through the gate, more particularly, data on the user's authentication process or fare adjustment process is sent/received between the gate device 200 and the radio unit 1 through the induced electromagnetic field. The received various data is outputted to the time counter 2 and then stored in its memory 26.

An essential portion of the wristwatch 100 will be described next with reference to FIGS. 1 and 3. FIG. 3 is an enlarged cross-sectional view of the essential portion of the wristwatch taken along a line III-III of FIG. 1.

As shown in FIGS. 1 and 3, the wristwatch 100 comprises a case 5 that houses a time counter 4. Two bands B are attached at one end to the case 5 at 12 and 6 o'clock at pivots B1 (in FIG. 3, only the pivot B1 at 6 o'clock is shown) to wear the wristwatch proper on the user's wrist.

An optically transparent crystal 6 is fitted through a gasket into an upper opening 54 in the case 5 with a bezel 7 provided over the upper end of the case 5.

A bottom cover 9 is attached through a waterproof ring 8 to a lower

end of the case 5 with a buffer 10 provided between the time counter 4 and the bottom cover 9.

Switches 51 are provided along the outer periphery of the case 5 to command the wristwatch 100 to fulfill various functions (see FIG. 1).

5

As shown in FIG. 3, the time counter 4 is composed of an upper housing 43; an analog hand mechanism 41, a dial plate 45 and a liquid crystal display 42 supported by the upper housing such that the analog hand mechanism 41, dial plate 45 and liquid crystal display 42 can be  
10 viewed from above the crystal 6; a lower housing 44 provided below the upper housing 43; and the radio unit 1.

The lower housing 44 houses batteries (not shown) that drive the respective components of the wristwatch 100 such as the analog hand  
15 mechanism 41 and the liquid crystal display 42. A circuit board 3 is disposed between the upper and lower housings 43 and 44 within a deeper opening 55 of the case 5 than the opening 54 into which the crystal 6 is fitted.

20 A dial plate 45, disposed on top of the upper housing 43, supports a ring-like frame 46 coaxially thereon. The dial plate 45, the upper housing 43, the circuit board 3 and the lower housing 44 are attached to an inner frame 52 within the case 5.

25 The analog hand mechanism 41 comprises a hand shaft 41a extending upward through a hole in the dial plate 45, hour, minute and second hands 41b attached to the hand shaft 41a, and a hand drive

mechanism 41c that drives the hands 41b around the shaft 41a above the dial plate 45.

Luminescent coatings 47 that become luminescent responsive to  
5 light emitted from light emitting elements (not shown) are provided at predetermined positions on the dial plate 45 and the hands 41b.

As shown in FIG. 3, the liquid crystal display 42 is disposed  
between the crystal 6 and the circuit board 3 within the case 5. The liquid  
10 crystal display 42 comprises liquid crystal cells sealed between a pair of optically transparent (upper and lower) plates each of which has a transparent electrode. The upper and lower transparent electrodes have an upper plate-like polarizer and a lower plate-like polarizer provided on an upper surface and a lower surface, respectively, thereof. A signal  
15 voltage is applied across the pair of transparent electrodes for the liquid crystal cells so as to display digitally various information including time. The various information displayed on the display 42 can be viewed through a window 45a provided in the dial plate 45.

20 The frame 46 is made, for example, of plastic and substantially in the form of a ring fitting coaxially within the cylindrical case 5 between the dial plate 45 and the crystal 6, as shown in FIG. 3. More particularly, the ring-like frame 46 is attached coaxially to the inside of the cylindrical hollow case 5 such that the frame 46 is held between the dial plate 45 and  
25 a bent ring-like frame part 14 of a flexible board 16 bonded to a lower surface of the crystal 6.

Then, the radio unit 1 will be described with reference to FIGS. 4A and 4B that are a plan view and a bottom view of the radio unit 1 as viewed from above and below, respectively, in FIG. 3.

As shown in FIGS. 4A and 4B, in the radio unit 1 the flexible board 5 16 comprises the ring-like frame part 14 and a lead 15 extending radially outward from the frame 14.

The frame part 14 is in the form of a ring following the opening 54 in the case 5 to which the crystal 6 is attached. A substantially helical coil 10 is attached to the upper and lower surfaces of the ring-like frame 14, thereby forming the antenna 11 that sends/receives information to/from the gate device 200. The ring-like frame part 14 comprises a wide area 141 from which the lead 15 extends radially outward. As shown in FIG. 4B, an IC chip 13 and a predetermined number of (3 in FIG. 4B) capacitors 12 15 connected electrically to the antenna 11 are provided on the back of the lead 15. Thus, the IC chip 13 is disposed close to the antenna 11, thereby reducing noise that would otherwise mix with a signal received by the antenna 11.

20 As shown in FIG. 3, the lead 15 is bent at a first bend line 151 at right angles to the ring-like frame part 14 so as to provide a section extending vertically between the inner surface of the case 5 and the outer surface of the ring-like frame 46, and further bent at a second lower bend line 152 radially inward at right angles to the vertical section. Thus, the 25 flexible board 16 takes substantially the form of a U.

As shown in FIG. 4B, terminals 17 are provided on the back of an

end portion of the lead 15 delimited by the second bend line 152 and connected electrically to the IC chip 13 through connection lines 15a and also to the circuit board 3.

Assembly of the radio unit 1 into the case 5 will be described next.

5 As shown in FIG. 3, a vertical passage 53 through which the lead 15 extends is provided between a first vertical surface including the outer peripheries of the ring-like frame 46, dial plate 45, upper housing 43, circuit board 3 and lower housing 44 and a second vertical surface coaxial with the first surface including the inner peripheries of the case 5 and  
10 inner frame 52.

The lower housing 44 has a recess 44a on its upper surface below the circuit board 3. As described above, the lowest bent portion of the lead 15 is received in the recess 44a such that the terminals 17 provided on the  
15 lowest bent portion are pushed against the terminals (not shown) of the circuit board 3 from below by a support 18 received in the recess 44a for electrical connection. The pushing force occurring in this case is adjustable depending on the thickness of the support 18 and the depth of the recess 44a.

20

As described above, in the radio unit 1 the ring-like frame part 14 is bonded to the lower surface of the crystal 6 and supported by the frame 46 from below. The vertical part of the lead 15 bent at the first bend line 151 from the ring-like frame part 14 extends downward through the vertical  
25 passage 53 along the outer vertical wall of the frame 46 and bent at the second bend line 152. This last bent portion is received within the recess 44a below the circuit board 3 such that the terminals 17 provided thereon

are pushed against the terminal connections provided on the circuit board 3, thereby establishing electrical connection.

As described above, according to the wristwatch 100 of this  
5 embodiment the ring-like frame part 14 on which the antenna 11 is  
coaxially disposed is provided within and near the open end of the case 5.  
The flexible board 16 of the radio unit 1 is provided such that the liquid  
crystal display 42 disposed within the case 5 can be viewed through the  
opening in the ring-like frame part 14. Thus, a sufficiently wide display  
10 area is ensured on the dial plate 45 and a long communication distance is  
ensured between the wristwatch 100 and the gate 200. The lead 15 of the  
flexible board 16 is bent at the first bend line 151 at the lower outer edge of  
the crystal 6. The lead 15 is further bent at the second bend line 152  
lower in position than the first bend line 151, thereby providing the end  
15 portion on which the connection terminals 17 are provided.

Thus, in manufacture, even when the circuit board 3 is disposed at  
a deeper position within the case 5, it can be easily connected electrically to  
the radio unit 1. Accordingly, high flexibility of disposing the circuit board  
20 3 within the case 5 is ensured and the radio unit 1 can be easily  
incorporated into the case 5.

Since the radio unit 1 is disposed within the case 5, it is difficult to  
remove the IC chip 13 from the wristwatch 100 and hence illegal  
25 acquirement of the information stored in the IC chip 13 by the third party  
is prevented.

<Embodiment 2>

A wristwatch 300 of the embodiment 2 will be described with reference to FIGS. 5 and 6, which are an enlarged plan view of the wristwatch 300 and an enlarged cross-sectional view of an essential portion  
5 of the wristwatch 300 taken along a line VI-VI of FIG. 5. Since the wristwatch 300 is the same in composition as that of the embodiment 1 excluding its radio unit 301 and further description thereof will be omitted. Like reference numerals are used to denote like parts.

10 As shown in FIGS. 5 and 6, in the radio unit 301 an IC chip 13 is provided on an end portion of a lead 315 integral with a ring-like frame part 314 of a flexible board 316 and delimited by a second bend line 152.

The radio unit 301 will be described in detail with reference to  
15 FIGS. 7A and 7B, which are a plan view and a back view, respectively, of the ring-like frame part 314 of the radio unit 301.

As shown in FIGS. 7A and 7B, an antenna 11 is composed of a ring-like helical coil provided coaxially on the ring-like frame part 314.  
20 The lead 315 has an end portion bent at a second bend line 152 which is greater in length than that of the lead 15 of the embodiment 1. The connection terminals 17 are disposed on a back of the end portion of the lead 315 with an IC chip 13 and a predetermined number of (3 in FIG. 7B) capacitors 12 disposed on the lead end portion between the connection  
25 terminals 17 and the second bend line 152. That is, in the present embodiment the IC chip 13 is disposed at a deeper position within the case 5 than the IC chip 13 provided in the wide area 141 of the frame part 14 in

the embodiment 1.

The IC chip 13 and the capacitors 12 are disposed in the recess 44a in the lower housing 44 when the radio unit 301 is incorporated into the  
5 case 5.

An identification code C for the radio unit 301 is marked at a predetermined position on the wristwatch 300 of this embodiment. More particularly, as shown in FIG. 5 an identification code C, for example of "ABCD EFGH 1234", is marked on the periphery of a lower surface of the  
10 crystal 6. The user can view the code C with the aid of light of a specified wavelength which is emitted from a light emitting element (not shown) when the switch 51 is operated by the user.

Alternatively, the arrangement may be such that the display output  
15 24 outputs display data involving the identification code C to the liquid crystal display 42 under control of the timepiece control 21, thereby causing the display 42 to display the identification code C.

As described above, according to the wristwatch 300 of this  
20 embodiment the IC chip 13 is disposed at the deeper position within the case 5 than in the embodiment 1. Thus, the IC chip 13 is difficult to remove from within the case 5 and hence illegal acquirement of the information stored in the IC chip 13 by the third party is prevented.

25 Even when the wristwatch 300 is decomposed in repair, the original wristwatch 300 can be easily reassembled with the aid of the identification code C, thereby avoiding leaving the wristwatch 300 in a decomposed state.

The shape of the radio unit 301 and the arrangement of the radio unit 301 within the case 5 are not limited to the above cases described.

<Modification 1>

5           FIG. 8 is a plan view of a wristwatch 400 as a modification 1. FIG. 9 is an enlarged cross-sectional view of an essential part of the wristwatch 400 taken along a line IX-IX of FIG. 8. As shown in FIGS. 8 and 9, in the wristwatch 400 an antenna 11 of a radio unit 601 disposed within the case 5 is viewable through the crystal 6.

10

          The wristwatch 400 has a vertical passage 453 provided in common through the ring-like frame 446, dial plate 45, upper housing 43 and circuit board 3 thereof at 6 o'clock. The ring-like frame 446 supports the crystal 6 at 46a from below and has an inward ring-like step 46b formed coaxially therewith on the inner wall thereof at an intermediate height below the  
15   crystal 6. A flexible board 416 has a vertical lead 415 extending through the vertical passage 453, an upper horizontal ring part 414 supported by the step 46b of the frame 446, and a lower horizontal portion bent at a second bend line 152 below circuit board 3.

20

          The upper ring-like frame part 414 of the flexible board 416 is bent horizontally and inwardly from the board 416 so as to be placed on the ring-like inward step 466.

25

          Thus, according to the wristwatch 400 the antenna 11 provided on the ring-like frame 414 can be viewed through the crystal 6. Therefore, the design and commercial value of the wristwatch 400 are enhanced by

the functional design employed in this modification.

<Modification 2>

FIG. 10 is an enlarged cross-sectional view of an essential part of a  
5 wristwatch 500 of a modification 2. The wristwatch 500 is the same in  
composition as the wristwatch 400 of the modification 1 excluding a flexible  
board 516 of a radio unit 501 and a ring-like frame part 546 thereof, and  
further description thereof will be omitted. Like reference numerals are  
used to denote like parts.

10

As shown in FIG. 10, the radio unit 501 is disposed within the case  
5 such that a ring-like frame part 514 thereof is supported coaxially by a  
dial plate 45. A ring-like frame 546 has a ring-like cut 46c provided  
coaxially on a lower end thereof along its inner periphery. The ring-like  
15 frame part 514 of the flexible board 516 is coaxially received snugly in its  
outer peripheral portion within the ring-like cut 46c provided in the  
ring-like frame 546. The vertical lead 515 of the flexible board 516  
integral with the upper bent ring-like frame part 514 extends through a  
vertical passage 553 extending downward through the dial plate 45, the  
20 upper housing 43 and the circuit board 3 and then bent at a second bend  
line 152 such that the resulting bent portion is received in a recess 44a in  
the lower housing 44 below circuit board 3.

Thus, according to the wristwatch 500 the flexible board 516 is bent  
25 at the first bend line 151 in accordance with the configuration of the  
bottom of the ring-like frame 546. Thus, in comparison to the wristwatch  
400 of the modification 1, in manufacture a processing time for the frame

546 required for disposing the radio unit 501 within the case 5 is reduced. Accordingly, the radio unit 501 can be more easily disposed within the case 5 and the radio unit 501 can be easily connected electrically to the circuit board 3 disposed at a deeper position within the case 5.

5

<Modification 3>

FIG. 11 is an enlarged cross-sectional view of an essential part of the wristwatch 600 according to a modification 3. FIG. 12 is a perspective view of a radio unit 601 provided within the wristwatch 600. The  
10 wristwatch 600 is the same in composition as the wristwatch 500 of the modification 2 excluding the configuration of a flexible board 616. Thus, further description thereof will be omitted. Like reference numerals are used to denote like parts.

15 As shown in FIGS. 11 and 12, in the radio unit 601 of the wristwatch 600 a ring-like frame part 614 of the flexible board 616 is fitted coaxially into a lower end of a ring-like frame 546. More specifically, the ring-like frame part 614 comprises a ring-like cylinder part 14a fitted coaxially into a lower open end 46d of the ring-like frame 546 and a  
20 flange-like support part 14b received snugly within a corresponding recess 46c provided on the lower end of the ring-like frame 546 and supported by the dial plate 45. A coil is formed on an inner surface of the ring-like cylinder part 14a, thereby constituting an antenna 611.

25 Thus, according to the wristwatch 600 the antenna 611 is disposed within the opening 54 in the case 5 to which the crystal 6 is attached. Thus, a long communication distance is ensured between the wristwatch

600 and the gate device 200. The antenna 611 is not disposed in an area of the dial plate 45 that the user can view. Thus, an area of the dial plate 45 where various information such as hour numerals is displayed is not limited by the antenna 611, thereby improving the commercial value of the  
5 wristwatch 600.

In each of the wristwatches 100, 300, 400, 500 and 600 according to the present invention, common information D such as the specifications of the radio units 1, 301, 401, 501 and 601 using the RF-ID system and the wristwatches 100 and matters to be attended to when each of these units  
10 and wristwatches is used may be indicated at a predetermined position on the wristwatch, more particularly, where the design of the wristwatch is not impaired, for example, on its bottom cover 9 (FIG. 13) or on the back of its bands B (FIG. 14). Thus, in accordance with the common information D indicated on the wristwatch 100 the user can use the RF-ID system  
15 effectively, thereby improving the commercial value of the wristwatch 100. Even when the wristwatch 100 is decomposed in repair, it can be easily reassembled with the aid of the common information D and identification code C because the decomposed parts of the wristwatch are not left in a dispersed state and can be related one to another.

20

According to the present invention, in manufacture the radio unit can be easily connected electrically to the circuit board disposed within the electronic apparatus through the connection terminals provided on the end portion of the lead of the radio unit.

25

In the radio unit, the ring-like frame part on which the antenna is disposed is provided within the electronic apparatus at a position near its

outer end where it is not a hindrance. Thus, even in this case a long communication distance is ensured between the wristwatch and an external communications device.

5           Such radio unit can be easily disposed within an electronic apparatus and is difficult to remove from the electronic apparatus. Thus, the integrated circuit disposed within the apparatus case is difficult to remove and hence illegal acquisition of information stored in the integrated circuit by the third party is prevented.

10

          In the radio unit, the integrated circuit is provided on the wider area of the ring-like frame part. Thus, the integrated circuit is disposed close to the antenna, thereby reducing a quantity of noise that would otherwise mix with a received antenna signal.

15

          In one radio unit, the helical antenna is provided coaxially with the ring-like vertical cylinder of the frame part on its inner surface within and near the outer end of the electronic apparatus. Thus, a long communication is ensured between the electronic apparatus and the gate  
20   device.

          In manufacture, the lead of the radio unit on whose end portion the connection terminals are provided is bendable in accordance with an internal configuration of the electronic apparatus. Thus, even when the  
25   radio unit is remote from the circuit board within the electronic apparatus, the radio unit can be easily connected electrically to the circuit board.

In the electronic apparatus comprising the radio unit according to the present invention, the display is disposed within the ring-like frame part on which the antenna is disposed. The ring-like frame part is in turn provided within the case on the side of its open-end to which the optically  
5 transparent crystal is attached. Thus, a sufficient display area and a long communication distance are ensured. In manufacture, the lead of the radio unit is bendable at the bend lines in accordance with the inside configuration of the apparatus case on the opposite side of the transparent crystal from the open end of the apparatus case. The connection terminals  
10 are provided on the end portion of the lead of the flexible board delimited by the nearer one of the two bend lines. Therefore, the circuit board can be easily connected electrically to the radio unit. Thus, the flexibility of disposing the circuit board within the case can be enhanced and the radio unit can be easily incorporated into the case. The radio unit is disposed  
15 within the case. Thus, the integrated circuit is difficult to remove from outside the electronic apparatus and illegal acquisition of the information stored in the integrated circuit by the third party is prevented.

Each of the leads 15, 315, 415 and 515 of the radio units 1, 301, 401,  
20 501 and 601 may take any shape as long as it can be bent at a predetermined bend line within the deeper opening 55 than the case opening 54, to which the crystal 6 is attached, in accordance with the inner configuration of a respective one of the wristwatches 100, 300, 400, 500 and 600 and its case 5.

25

While in the embodiments the frame part of each of the flexible boards 14, 314, 414, 514 and 614 is illustrated substantially in the form of

a ring, the present invention is not limited to these respective shapes. The frame part may take any shape as long as it follows the inner configuration of the opening 54 in the case 5 to which the crystal 6 is attached.

5

While in one embodiment the wristwatch 100 is illustrated as the electronic apparatus, the present invention is also applicable to any particular electronic apparatus as long as the radio unit 1 can be incorporated into the particular electronic apparatus.

10

Various modifications and changes may be made without departing from the broad spirit and scope of this invention. The above-described embodiments are intended to illustrate the present invention, not to limit the scope of the present invention. The scope of the present invention is shown by the attached claims rather than the embodiments. Various  
15 modifications made within the meaning of an equivalent of the claims of the invention and within the claims are to be regarded to be in the scope of the present invention.

Claims:

1. A radio unit (FIGS. 1-4A, 4B) comprising:  
a flexible board (16) that comprises a frame part (14) and a lead (15) extending outward from the frame part;  
5 an antenna (11) disposed on the frame part for sending/receiving information to/from an external communications device (200);  
an integrated circuit (13) disposed on the frame part and connected electrically to the antenna; and  
a connection terminal (17) provided on an end portion of the lead  
10 for connection of the integrated circuit with a circuit board (3) of an electronic apparatus (100).
2. The radio unit (FIGS. 1, 3, 4A, 4B) of claim 1, wherein the frame part comprises a wide area (141) on which the integrated circuit is  
15 provided.
3. The radio unit (FIGS. 4A, 4B) of claim 1, wherein the lead is bent at bend lines (151, 152) in accordance with the inner configuration of the electronic apparatus.  
20
4. An electronic apparatus (100 in FIGS. 1-4A, 4B) comprising:  
a case (5) having an open end (54);  
an optically transparent member (6) attached to the open end (54);  
a display (42) disposed at a deeper position than the transparent  
25 member within the case so as to face the transparent member for displaying various information;  
a circuit board (3) disposed at a position inner than the display

within the case; and

a radio unit (1) disposed within the case, and wherein:

the radio unit comprises:

a flexible board (16) that in turn comprises a frame part (14) having  
5 a ring-like form following the inner configuration of the open end in the  
case (54) and disposed between the transparent member and the display  
such that the display can be viewed through the transparent member from  
the outside, and a lead (15) extending outward from the frame part and  
bent at bend lines (151, 152) in accordance with the inner configuration of  
10 the case;

an antenna (11) provided on the frame part for sending/receiving  
information to/from an external communications device (200);

an integrated circuit (13) provided on the frame part and  
electrically connected to the antenna; and

15 a connection terminal (17) provided on an end portion of the lead  
delimited by the nearer one of the bend lines for connecting the integrated  
circuit electrically with the circuit board.

5. A radio unit (301, 401, 501, 601 in FIGS. 2, 5-12)  
20 comprising:

a flexible board (316, 416, 516, 616) in turn comprising a ring-like  
frame part (314, 414, 514, 614) and a lead (315, 415, 515) extending  
outwardly from the frame part;

a ring-like antenna (11, 611) disposed on the frame part for  
25 sending/receiving information to/from an external communications device  
(200);

an integrated circuit (13) disposed on the lead and connected

electrically to the antenna; and

a connection terminal (17) provided on an end portion of the lead for electrically connecting the integrated circuit with an electronic apparatus (300, 400, 500, 600).

5

6. The radio unit (FIGS. 11, 12) of claim 5, wherein the frame part comprises a flange-like base (14b) and a ring-like vertical hollow cylinder (14a) integral at its lower end with the base; and the antenna being provided on the vertical cylinder.

10

7. The radio unit (FIGS. 7A, 7B) of claim 5, wherein the lead part is bent at bend lines (151, 152) in accordance with the inner configuration of the electronic apparatus.

15

8. An electronic apparatus (300, 400, 500, 600 in FIGS. 2, 5-12) comprising:

a case (5) having an open end (54);

an optically transparent member (6) attached to the open end (54);

a display (42) disposed at a deeper position than the transparent

20 member within the case so as to face the transparent member for displaying various information;

a circuit board (3) disposed at a position inner than the display within the case; and

25 a ring-like frame (46, 446, 546) received coaxially within the case between the optically transparent member and the display;

a radio unit (301, 401, 501, 601) disposed within the case, and wherein:

the radio unit comprises:

a flexible board (16) that in turn comprises a frame part (314, 414, 514, 614) having a ring-like form following the inner configuration of the open end (54) in the case and disposed between the transparent member  
5 and the ring-like frame such that the display can be viewed through the transparent member from the outside, and a lead (315, 415, 515) extending outward from the frame part and bent at bend lines (151, 152) in accordance with the inner configuration of the case;

an antenna (11, 611) provided on the frame part for  
10 sending/receiving information to/from an external communications device (200);

an integrated circuit (13) provided on the lead and electrically connected to the antenna; and

a connection terminal (17) provided on an end portion of the lead  
15 for connecting the integrated circuit electrically with the circuit board.