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CA 2273091 C 2004/06/29

(11)(21) 2 273 091

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 1997/11/25
(87) Date publication PCT/PCT Publication Date: 1998/06/11
(45) Date de délivrance/Issue Date: 2004/06/29
(85) Entrée phase nationale/National Entry: 1999/05/27
(86) N° demande PCT/PCT Application No.: US 1997/021600
(87) N° publication PCT/PCT Publication No.: 1998/025323
(30) Priorité/Priority: 1996/12/04 (08/760,024) US

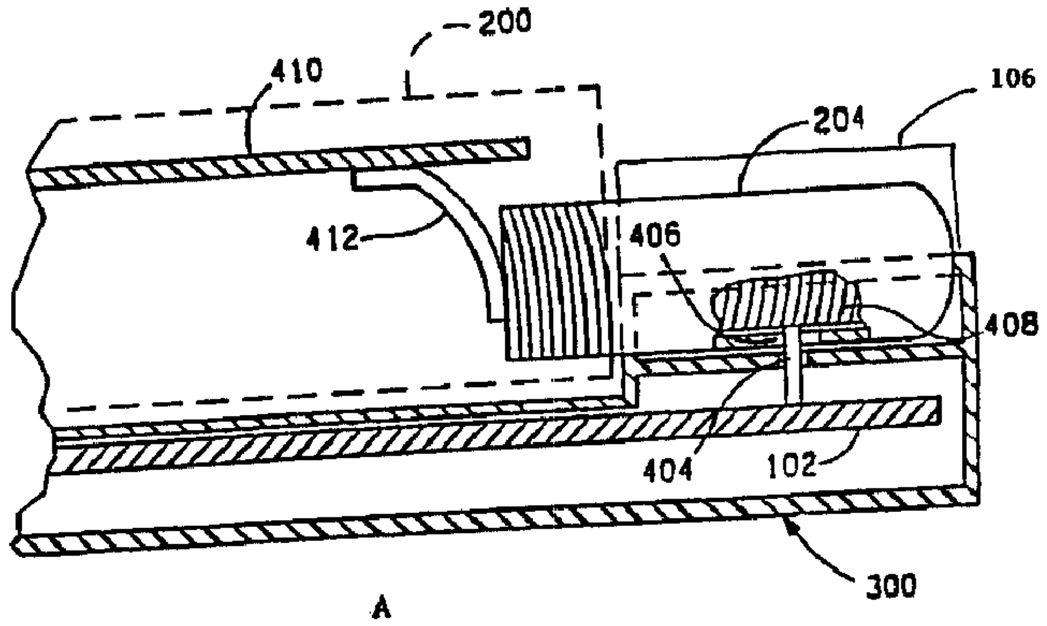
(51) Cl.Int.^{6}/Int.Cl.^{6} H01Q 1/24, H03H 7/46, H04B 1/38

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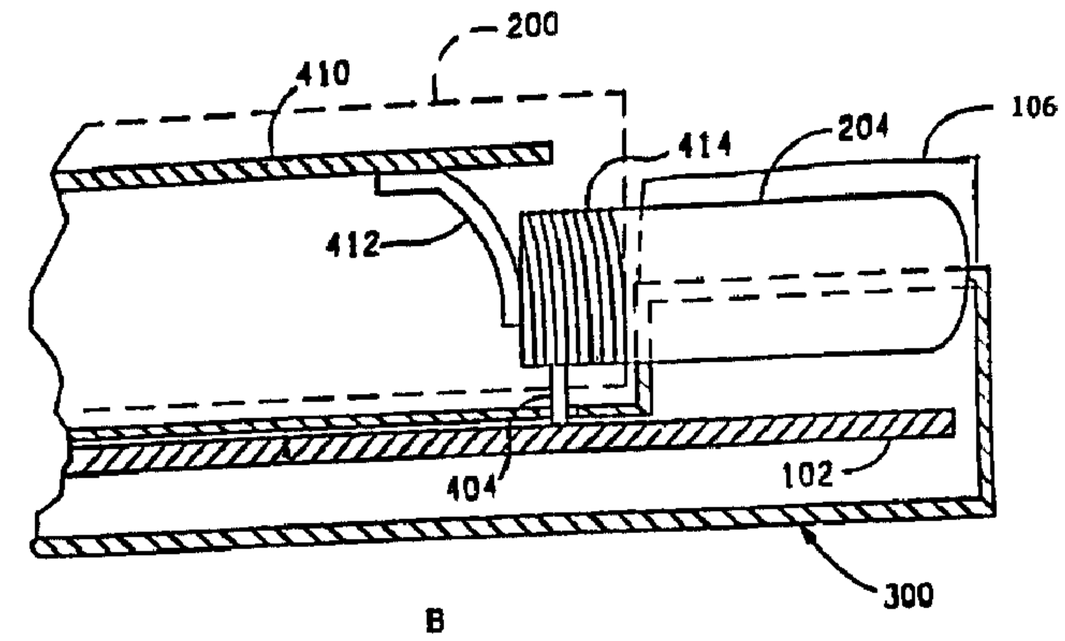
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(54) Titre : COUPLEUR D'ANTENNE DOUBLE BANDE POUR RADIOTELEPHONE PORTABLE
(54) Title: DUAL-BAND ANTENNA COUPLER FOR A PORTABLE RADIOTELEPHONE



A



B

(57) Abrégé/Abstract:
A dual-band antenna coupler (100) for use in an adapter for portable radiotelephone (200). A plurality of curved bands of metal (204a-c) are positioned on a ground plane (102), with at least two of the plurality of curved bands (204a, 204b) of metal being

CA 2273091 C 2004/06/29

(11)(21) 2 273 091

(13) C

(57) Abrégé(suite)/Abstract(continued):
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CORRECTED VERSION*

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [6] :
H01Q 1/24, H03H 7/46, H04B 1/38

A1

(11) International Publication Number: **WO 98/25323**

(43) International Publication Date: 11 June 1998 (11.06.98)

(21) International Application Number: PCT/US97/21600

(22) International Filing Date: 25 November 1997 (25.11.97)

(30) Priority Data:
760,024 — 4 December 1996 (04.12.96) — US

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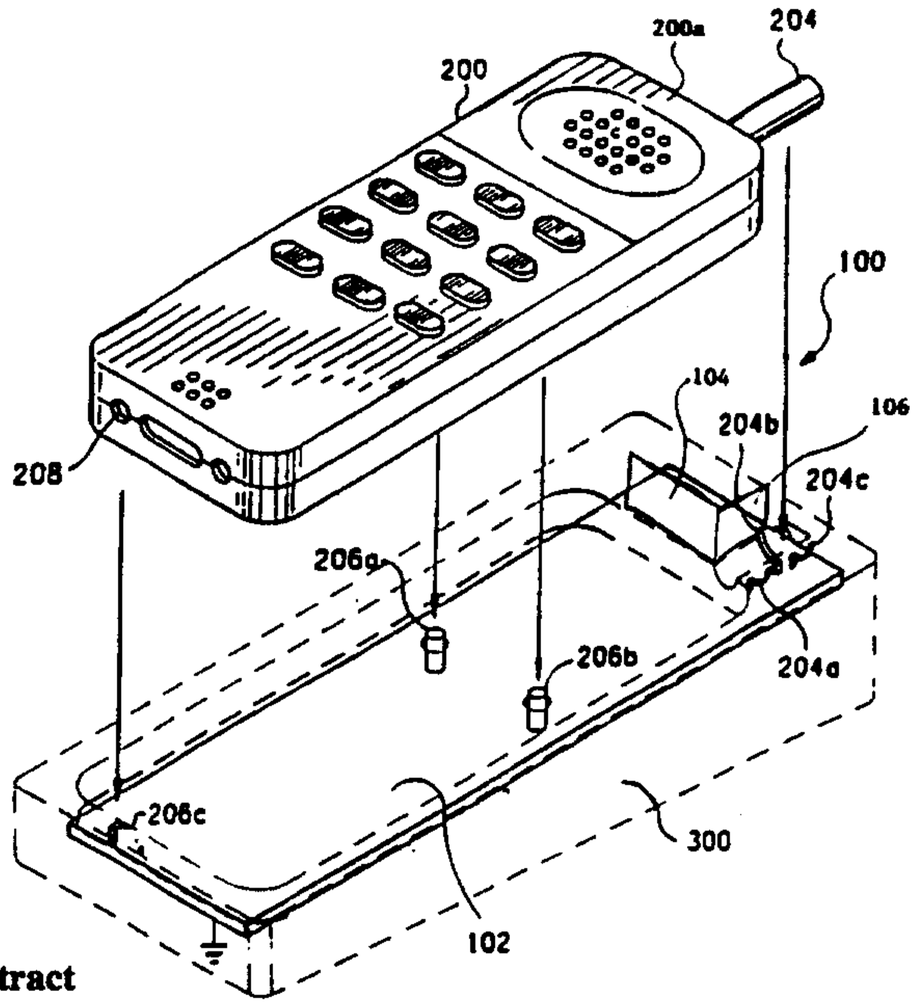
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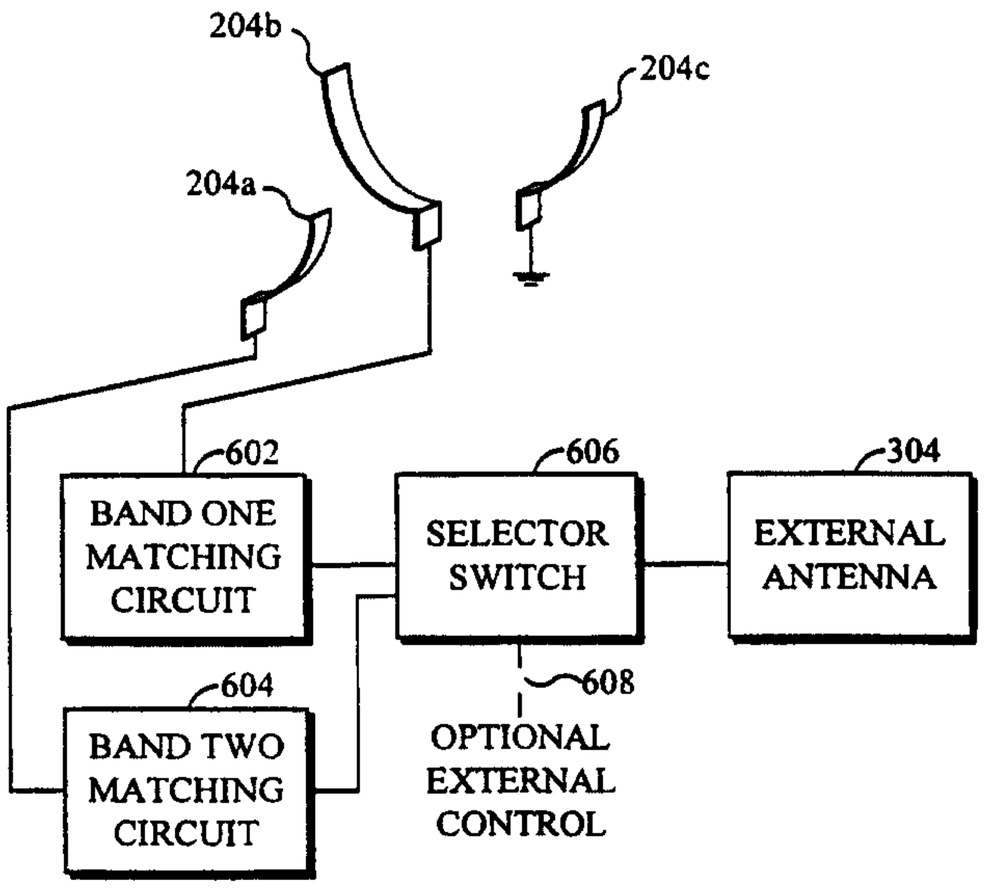
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(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: DUAL–BAND ANTENNA COUPLER FOR A PORTABLE RADIOTELEPHONE





(57) Abstract

A dual–band antenna coupler (100) for use in an adapter for portable radiotelephone (200). A plurality of curved bands of metal (204a–c) are positioned on a ground plane (102), with at least two of the plurality of curved bands (204a, 204b) of metal being electrically isolated from the ground plane (102) so as to couple radio frequency (RF) signals to and from the antenna (204) of the portable radiotelephone (200). The isolated curved bands (204a, 204b) of metal couple RF signals between the antenna (204) of the portable radiotelephone and first and second matching circuits (602, 604) designed to match the portable radiotelephone antenna (204) at each of the respective frequency bands. A selector switch (606) coupled to the output of the matching circuits (602, 604) selects the appropriate matching circuit output for connection to an external antenna (304). The adapter also includes at least one ground pin (206a–c) mounted on the ground plane (102). When the portable radiotelephone (200) is interfaced with the antenna coupler (100), the ground pin (206a–c) makes electrical contact with a ground reference connection on the portable radiotelephone (202a, 202b, 208).

*(Referred to in PCT Gazette No. 41/1998, Section II)

WO 98/25323 PCT/US97/21600

DUAL-BAND ANTENNA COUPLER FOR A PORTABLE RADIOTELEPHONE

BACKGROUND OF THE INVENTION

I. Field of the Invention

The present invention relates generally to antenna couplers. More particularly, the present invention is directed to a novel and improved antenna coupler for a portable radiotelephone.

II. Description of the Related Art

In the field of cellular communications, portable radiotelephones are used to communicate with base stations over radio-frequencies (RF). Typically, these portable radiotelephones operate at relatively low power levels in order to conserve battery power and increase talk time. However, when there are alternate power means available, such as a vehicle battery when driving, or a conventional electrical outlet when indoors, the user of the portable radiotelephone often employs special adapters to take advantage of the higher power supply available. For example, there are many vehicular adapters which transform the vehicle-generated electrical supply into a level suitable for use by the portable telephone, and also couple the RF signals to and from the portable radiotelephone for use with an external power booster and antenna. Additionally, these adapters may include a "hands-free" kit including an auxiliary microphone and speaker. In this way, the user may take advantage of higher power transmission and hands-free conversation without sacrificing battery time, and yet still be able to carry the same portable radiotelephone with him when he leaves his car.

In order to couple the RF signal to and from the portable radiotelephone, a typical vehicular adapter uses an inductive coupler placed close to the portable radiotelephone's antenna. However, this technique may result in a significant amount of RF signal energy loss, particularly when an insufficient RF return path, or ground, is provided to the portable radiotelephone while it is in the adapter. Since a typical portable radiotelephone's internal components are encased in an electromagnetic interference (EMI) shield to prevent stray electromagnetic energy leaking from the radiotelephone's casing, the prior art vehicular adapters have not been able to achieve a sufficient RF return path to the portable radiotelephone.

SUMMARY OF THE INVENTION

According to the invention, there is provided an antenna coupling device for coupling radio frequency signals from a communication device having an antenna and at least one externally accessible ground point, the communication device operable in a first frequency band and a second frequency band, the antenna coupling device comprising: a ground plane having an upper surface; an antenna coupler mounted on said ground plane upper surface, for coupling radio signals to and from the communication device antenna; at least one ground pin, coupled to said upper surface of said ground plane, for contacting the at least one externally accessible ground point; and a matching circuit coupled to said antenna coupler to generate a predetermined impedance to match said antenna coupler to the communication device antenna at each of the first frequency band and the second frequency band.

According to the invention, there is also provided an antenna coupling device for coupling radio frequency signals from a communication device having an internal antenna and at least one externally accessible ground point, the communication device operable in two frequency bands, the antenna coupler comprising: a connector coupleable to an external antenna; a ground plane having an upper surface and sized to match the communication device; an antenna coupler mounted on said ground plane upper surface, for coupling radio signals between the communication device antenna and said external antenna connector; at least one ground pin, coupled to said upper surface of said ground plane, for contacting the externally accessible ground point; and a matching circuit coupled to said antenna coupler to receive the radio frequency signals and to generate a predetermined impedance to match said antenna

coupler to the communication device antenna and said external antenna connector at each of the first frequency band and the second frequency band.

The present invention is embodied in an antenna coupling device used to adapt a portable radiotelephone capable of operation in two frequency bands. The antenna coupling device comprises a ground plane having an upper surface with an antenna coupler mounted on the upper surface. The antenna coupler couples radio signals to and from the communication device antenna. The ground plane also includes at least one ground pin capable of contacting an externally accessible ground point on the radio communication device. A matching circuit coupled to the antenna coupler generates a predetermined impedance to match the antenna coupler to the communication device antenna at each of the first and second frequency bands.

The ground plane may also include first and second abutting vertical portions mounted on the upper surface thereof. The first and second abutting vertical portions are positioned in a substantially orthogonal relation to each other and to the ground plane upper surface. In a first embodiment, a plurality of curved metal bands are positioned in proximity with the ground plane with a first of the curved bands being electrically isolated from the ground plane to couple radio signals to and from the communication device antenna when the communication device is operating in a first of the two frequency bands. A second of the curved bands is also electrically isolated from the ground plane to couple radio signals to and from the communication device antenna when the communication device is operating in a second of the two frequency bands. A third of the curved bands is electrically coupled to the ground plane. The matching circuit may comprise first and

second matching circuit portions each having an input terminal to match the communication device antenna. The first matching circuit portion is used when the communication device is operating in the first frequency band and the second matching circuit portion is operational when the communication device is operating in the second frequency band. The input terminal of the first matching circuit portion is coupled to the first curved band while the second matching circuit portion input terminal is coupled to the second curved band.

In a second embodiment, a coupling pin makes direct contact with a radio frequency component of the communication device, such as the communication device antenna. In this embodiment, there is no need to couple the signal over the air using the curved bands. The output from the

coupling pin may be connected to a single dual-band matching circuit designed to generate a predetermined impedance to match the antenna coupler to the communication device antenna at each of the first and second frequency bands. Alternatively, the coupling device may include a switch circuit coupled between the coupling pin and first and second matching circuit portions. The switch circuit couples the coupling pin to the first matching circuit portion for operation of the communication device in the first frequency band and couples the coupling pin to the second matching circuit portion for operation of the communication device in the second frequency band.

In yet a third embodiment, a helical coupler surrounds at least a portion of the communication device antenna and couples the radio frequency signals over the air.

The signals from the matching circuit or matching circuit portions may be optionally connected to a booster amplifier and connected to an external antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

The features, objects, and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference characters identify correspondingly throughout and wherein:

FIG. 1A is an illustration of an exemplary portable radiotelephone suitable for use with the present invention;

FIG. 1B is an illustration of a first embodiment antenna coupler of the present invention interfacing with an exemplary portable radiotelephone;

FIG. 2A is an illustration of one embodiment of the coupling elements of the present invention;

FIG. 2B is an illustration of an alternate embodiment of the coupling elements of the present invention;

FIG. 3A is an illustration of a second embodiment of the antenna coupler of the present invention interfacing with a direct connection to an exemplary portable radiotelephone antenna, shown in a partially cut-away view;

FIG. 3B is an illustration of a second embodiment of the coupling elements of the present invention interfacing with a direct connection to an internal component of an exemplary portable radiotelephone;

FIG. 4A is an illustration of a third embodiment antenna coupler of the present invention interfacing with an exemplary portable radiotelephone; and

FIG. 4B is an illustration of the helical coupler of the third embodiment of the present invention interfacing with an antenna of an exemplary portable radiotelephone;

FIG. 5A is an illustration of one embodiment of the dual-band coupling elements of the present invention;

FIG. 5B is an illustration of an alternative embodiment of the dual-band coupling elements of the present invention;

FIG. 6 is a functional block diagram of a dual-band matching circuit used with the antenna coupler of FIGs. 3A, 3B, 4A, and 4B;

FIG. 7 is an alternative embodiment of the dual-band matching circuit used with the antenna coupler of FIGs. 3A, 3B, 4A, and 4B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1B, a first embodiment of the antenna coupler **100** of the present invention comprises ground plane **102**, abutting vertical ground plane portions **104** and **106**, coupling elements **204a**, **204b**, and **204c**, ground pins **206a**, and **206b**, and optional ground pin **206c**. Coupling elements **204a**, **204b**, and **204c** are preferably constructed of vertically facing, curved bands of a conductive material, such as copper, steel, or the like. When portable radiotelephone **200** is interfaced with antenna coupler **100**, coupling elements **204a**, **204b**, and **204c** receive retracted helix antenna **204** of portable radiotelephone **200** and couple RF signals to and from antenna **204**. Coupling elements **204a**, **204b**, and **204c** are constructed and positioned in such a way that when portable radiotelephone **200** is interfaced with antenna coupler **100**, coupling elements **204a**, **204b**, and **204c** extend in a semi-circular array, each covering approximately one-quarter of the circumference of antenna **204**. It should be noted that antenna **204** may also be of a non-helical construction as is known in the art, such as a rod or loop antenna. It should also be noted that portable radiotelephone **200** may generally be any type of mobile communication device, such as a cellular or PCS radiotelephone, or a wireless local loop communication device.

Coupling elements **204a**, **204b**, and **204c** are mounted at a respective coupler base to ground plane **102**. In the preferred embodiment, ground plane **102** is a double-sided printed wiring board (PWB). However, a single-

sided PWB would also provide an adequate construction for ground plane **102**, or any large base coated with a layer of conductive material. Ground plane **102** provides an improved return path for RF energy from antenna **204** to a ground reference point within portable radiotelephone **200**. Abutting vertical ground plane portions **104** and **106** also serve to improve the return path for RF energy from antenna **204** to a ground reference in radiotelephone **200**. Abutting vertical ground plane portion **104** is positioned in a substantially parallel arrangement with respect to a top surface **200a** (see FIG. 1B) of radiotelephone **200** when the radiotelephone is used with antenna coupler **100**. Abutting vertical ground plane portion **106** is positioned in a substantially orthogonal position with respect to abutting vertical ground plane portion **104** thus placing abutting vertical ground plane portion **106** in a substantially parallel position with respect to a longitudinal axis of antenna **204** (see FIG. 1B).

In order to couple RF energy from antenna **204**, at least one of coupling elements **204a**, **204b**, and **204c** is electrically isolated from ground plane **102**. Ground plane **102** also serves to electrically couple ground pins **206a**, **206b**, and (optionally) **206c** to at least one of coupling elements **204a**, **204b**, and **204c**. That is to say that each of ground pins **206a-206c**, ground plane **102**, and at least one of coupling elements **204a-204c** share the same electrical ground potential. As such, a complete RF signal path may be provided for coupling of RF signals to and from antenna **204** by connecting ground pins **206a**, **206b**, and (optionally) **206c** to a suitable ground on portable radiotelephone **200**.

An exemplary connection scheme of the coupling elements **204a-204c** of the present invention is seen in FIG. 2A. In FIG. 2A, coupling elements **204a** and **204b** are connected together, and electrically isolated from ground plane **102**, while connector **204c** is connected directly to ground plane **102**. For signal transmission utilizing the present invention, RF signals from portable radiotelephone **200** (see FIG. 1B) are transmitted over the air by antenna **204**. Coupling elements **204a** and **204b** couple off the RF energy from antenna **204** and pass it to matching circuit **110** which provides an impedance match between power booster **302** and antenna coupler **100**. Optional power booster **302** increases the power of the RF signal coupled from antenna **204** and passes the resulting high-power signal to external antenna **304** for over-the-air transmission. For reception, the reverse signal flow occurs. RF signals received by external antenna **304** are optionally passed through power booster **302** and matching circuit **110** to coupling

elements **204a** and **204b** where the signal energy is coupled to antenna **204** of portable radiotelephone **200**.

An alternative connection scheme of the coupling elements **204a-204c** is illustrated in FIG. 2B. FIG. 2B is similar to FIG. 2A, except that it is the outer two coupling elements, **204a** and **204c** which are both connected to ground plane **102**, and only the inner coupling element **204b** is electrically isolated from ground plane **102** and connected to matching circuit **110**. This alternative arrangement of FIG. 2B has different RF characteristics than that of FIG. 2A, and may be more suitable for different operating frequency ranges or antenna structures.

Referring now to FIG. 1B, ground pins **206a** and **206b** make electrical contact with assembly screws **202a** and **202b** (see FIG. 1A) of portable radiotelephone **200**. Since these assembly screws penetrate the internal electromagnetic shield (not shown) enclosing the internal components of portable radiotelephone **200**, they improve the contact between the ground of antenna coupler **100** and portable radiotelephone **200**. Although there is typically no direct contact between the assembly screws **202a** and **202b** of portable radiotelephone **200** and the internal electromagnetic interference (EMI) shield (not shown), the screws pass through the edges of the shield, providing sufficient ground potential. In the preferred embodiment, ground pins **206a** and **206b** are spring-loaded to ensure reliable contact with assembly screws **202a** and **202b**. Alternatively, radiotelephone **200** may be designed such that assembly screws **202a** and **202b** make direct physical contact with the internal EMI shield.

Direct contact may also be made between the ground plane **102** and the internal ground of portable radiotelephone **200** through ground pin **206c**, which makes contact with battery ground port **208** of portable radiotelephone **200**. In this optional configuration, coupling between the internal ground of portable radiotelephone **200** and ground plane **102** may also be accomplished. It should be understood that although the exemplary embodiment illustrated in FIG. 1 comprises three ground pins **206a**, **206b**, and **206c**, alternate embodiments may comprise more or fewer pins to accomplish the same function.

In a second embodiment of the antenna coupler of the present invention shown in FIGs. 3A and 3B, coupling elements **204a**, **204b**, and **204c** of FIG. 1 are replaced with a direct contact coupling pin **404**. Direct contact coupling pin **404** is mounted to, but electrically isolated from, ground plane **102**. Direct contact coupling pin **404** makes physical contact with an internal component in the RF chain of radiotelephone **200**. For example, if antenna

204 is encased in an insulative material, such as plastic, direct contact coupling pin 404 makes physical contact with the internal electrically conductive portion 408 of antenna 204 through a small opening 406 in the outer protective casing of antenna 204, as shown in FIG. 3A. Alternatively, portable radiotelephone 200 may have a small opening in its protective casing for direct contact coupling pin 404 to make physical contact with antenna nut 414 or antenna clip 412, or any suitable component in the RF chain of circuit board 410, all internal to portable radiotelephone 200. Direct contact of coupling pin 404 to an internal component in the RF chain of radiotelephone 200 as shown in either FIG. 3A or 3B obviates the need for the multiple coupler configuration associated with over-the-air coupling as shown in FIGs. 1 and 2. Again, it should be noted that antenna 204 may be of a non-helical design such as a rod or loop or other antenna design as is known in the art.

In a third embodiment of the antenna coupler 100 shown in FIGs. 4A and 4B, coupling elements 204a-204c may be replaced by a helical coupler 504. In this embodiment, when portable radiotelephone 200 is interfaced with antenna coupler 100, antenna 204 is inserted along a longitudinal axis within helical coupler 504. Helical coupler 504 is preferably constructed from a conductive wire such as copper, steel, or the like. RF coupling is accomplished over the air, similarly to that of coupling elements 204a-204c. However, in contrast to the semi-circular array arrangement of coupling elements 204a-204c as shown in FIG. 1, helical coupler 504 completely surrounds antenna 204. Also, helical coupler 504 is electrically isolated from ground plane 102. The embodiment of FIGs. 4A and 4B has different RF characteristics than that of FIGs. 1A and 1B or 3A and 3B, and may be more suitable for different operating frequency ranges or antenna structures.

Often, portable radiotelephone 200 is designed to operate in two separate frequency bands, such as operation in one frequency band designated for personal communications system (PCS) and a second frequency band designated for cellular telephone operation. When portable radiotelephone 200 is operational in two bands, it is desirable to provide appropriate matching circuits for antenna coupler 100 to maximize performance in each of the two bands. Some prior art portable radiotelephones include a terminal for direct coupling between the RF circuitry of the radiotelephone and an external antenna. A switch (not shown) inside the radiotelephone enables operation with the internal antenna or external antenna. However, the internal switch results in an insertion loss and subsequent decrease in RF output even when the portable

radiotelephone is used with the internal antenna. The dual-band antenna coupler of the present invention overcomes this shortcoming by eliminating the internal antenna switching circuitry.

A dual-band implementation of antenna coupler **100** is illustrated in FIG. 5A. Outer coupling element **204c** is coupled to ground plane **102** while coupling elements **204a** and **204b** are electrically isolated from ground plane **102**. Inner coupling element **204b** couples RF energy from antenna **204** (see FIG. 1B) to a band one matching circuit **602**. Band one matching circuit **602** is designed to match antenna **204** for operation at frequencies in a first band. Coupling element **204a** couples RF energy from antenna **204** to a band two matching circuit **604**. Band two matching circuit **604** is designed to match antenna **204** for operation at frequencies in a second band. The outputs of band one matching circuit **602** and band two matching circuit **604** are coupled to a selector switch **606**. Selector switch **606** selects the output from one of the band matching circuits for coupling to external antenna **304**.

Selector switch **606** may be any type of switching device such as a block diplexer, diode switch, transmission line diplexer, transistor switch, passive circuit, or the like. The operation of these conventional switching circuits is well known in the art and need not be described in greater detail herein. Also shown in FIG. 5A is an optional external control **608** for selector switch **606**. With this optional embodiment, selector switch **606** may be digitally controlled by signals from portable radiotelephone **200**. As is known in the art, dual-band radiotelephones typically include a serial output port which may be used to generate a control signal coupled to optional external control **608**. Thus, selector switch **606** may be controlled by signals generated by portable radiotelephone **200**.

An alternative connection scheme for coupling elements **204a-204c** is illustrated in FIG. 5B. The operation of the circuit of FIG. 5B is identical to that of FIG. 5A, except that outer coupling element **204a** is electrically connected to ground plane **102** in FIG. 5B while outer coupling element **204c** is electrically isolated from ground plane and is used to couple RF energy from antenna **204** to band two matching circuit **604**. The alternative arrangement of FIG. 5B has different RF characteristics than that of FIG. 2A, and may be more suitable for different operating frequency ranges or antenna structures.

The dual-band matching circuit of the present invention is also useful with embodiments of antenna coupler **100** illustrated in FIGs. 3A, 3B, 4A, and 4B. In the embodiments of antenna coupler **100** illustrated in FIGs. 5A and 5B, separate inputs are provided to band one matching circuit **602** and

band two matching circuit **604** from the various antenna coupling elements **204a-204c**. However, in the embodiments of antenna coupler **100** illustrated in FIGs. 3A, 3B, 4A, and 4B, RF signals are coupled from portable radiotelephone **200** via direct contact coupling pin **404** (see FIGs. 3A and 3B) or by helical coupler **504** (see FIGs. 4A and 4B). In FIG. 6, band one matching circuit **602** and band two matching circuit **604** are coupled to a single antenna lead **700** by switching circuit **702**. Switching circuit **702** couples RF energy from antenna **204** to the matching circuit for the appropriate frequency band. Band one matching circuit **602**, band two matching circuit **604**, and selector switch **606** operate in the manner described above. Switching circuit **702** may be one of a number of known switching circuits, such as a block diplexer, diode switch, transmission line diplexer, transistor switch, passive circuit, or the like. FIG. 6 also illustrates an optional external control line **704** to control operation of switching circuit **702**. As previously discussed with respect to selector switch **606**, radiotelephone **200** may provide digital control signals through a serial port to control selection of both selector switch **606** and switching circuit **702**.

As those of ordinary skill in the art will recognize, the electrical circuitry for band one matching circuit **602** and band two matching circuit **604** may be combined in a single dual-band matching circuit **800** illustrated in FIG. 7. Dual-band matching circuit **800** is designed for optimized performance over both frequency bands. However, as those of skill in the art can appreciate, a combination matching circuit is not as well optimized as two individual circuits, such as band one matching circuit **602** and band two matching circuit **604**. However, the advantage of the single dual-band matching circuit **800** is that it eliminates the need for selector switch **606** and switching circuit **702** if antenna coupler **100** uses single antenna lead **700**. However, there are techniques to optimize performance of dual-band matching circuit **800**. For operation with helical coupler **504** (see FIGs. 4A and 4B), helical coupler **504** can be optimized for dual-band operation with antenna **204**. Alternatively, dual-band matching circuit **800** can be optimized for performance over two frequency bands through the use of lumped passive components or through the use of transmission line matching using tuning stubs **802** and **804** as resonators for PCS and cellular band operation, respectively.

In each of the above embodiments, antenna coupler **100** may be encased in a plastic or other non-conductive housing assembly **300** or the like in order to protect coupling elements **204a-204c**, ground pins **206a-206c** and ground plane **102** from damage, and to provide support for the structure

of antenna coupler **100**. Preferably, the housing assembly **300** encasing antenna coupler **100** would have a receptacle on a top face for receiving and securely capturing the portable radiotelephone **200** such that antenna **204** is brought within close proximity to coupling elements **204a-204c**, and ground pins **206a-206c** are physically aligned with, and securely mate with, the externally accessible grounds on portable radiotelephone **200**, *i.e.*, assembly screws **202** and/or battery ground port **206**. Clearly, many different designs for the housing assembly **300** may be used without departing from the inventive concept of the present invention. For example, the housing assembly **300** may be fixedly mounted to a vehicle dash board. Alternatively, housing assembly **300** may be a more portable hand-held design that may be held close to the user's head.

The previous description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. The various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without the use of the inventive faculty. Thus, the present invention is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope consistent with the principles and novel features disclosed herein.

I CLAIM:

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CLAIMS:

1. An antenna coupling device for coupling radio frequency signals from a communication device having an antenna and at least one externally accessible ground point, the communication device operable in a first frequency band and a second frequency band, the antenna coupling device comprising:

a ground plane having an upper surface;

an antenna coupler mounted on said ground plane upper surface, for coupling radio signals to and from the communication device antenna;

at least one ground pin, coupled to said upper surface of said ground plane, for contacting the at least one externally accessible ground point; and

a matching circuit coupled to said antenna coupler to generate a predetermined impedance to match said antenna coupler to the communication device antenna at each of the first frequency band and the second frequency band.

2. The coupling device of claim 1 wherein said ground plane includes first and second abutting vertical portions mounted on said upper surface, said first and second abutting vertical portions being positioned in a substantially orthogonal relation to each other and to said upper surface.

3. The coupling device of claim 1 wherein said matching circuit comprises a first matching circuit for operation of the communication device in the first frequency band and a second matching circuit for operation of the communication device in the second frequency band.

4. The coupling device of claim 3 wherein said first and second matching circuits each have an independent output terminal, the coupler further including a selection circuit coupled to said first and second matching circuit output terminals to couple a selected one of said independent output terminals to a device output terminal.

5. The coupling device of claim 1 wherein said antenna coupler comprises a plurality of upward facing curved bands of metal, a first of said curved bands being electrically isolated from said ground plane to couple radio signals to and from the communication device antenna when the communication device is operating in the first frequency band, a second of said curved bands being electrically isolated from said ground plane to couple radio signals to and from the communication device antenna when the communication device is operating in the second frequency band, and a third of said curved bands of metal being electrically coupled to said ground plane.

6. The coupling device of claim 5 wherein said matching circuit comprises a first matching circuit portion having an input terminal to match the communication device antenna when the communications device is operating in said first frequency band and a second matching circuit portion having an input terminal to match the communication device antenna when the communications device is operating in said second frequency band, said first matching circuit portion input terminal being coupled to said first of said curved bands, said second matching circuit portion input terminal being coupled to said second of said curved bands.

7. The coupling device of claim 1 wherein said antenna coupler comprises a metal pin sized to permit physical contact with the communication device antenna when

the communication device is operable with the coupling device.

8. The coupling device of claim 7 wherein said matching circuit is a dual-band matching circuit coupled to said antenna coupler to generate a predetermined impedance to substantially match said antenna coupler to the communication device antenna at each of the first frequency band and the second frequency band.

9. The coupling device of claim 7 wherein said matching circuit comprises a first matching circuit portion for operation of the communication device in the first frequency band and a second matching circuit portion for operation of the communication device in the second frequency band, the coupling device further including a switch circuit coupled between said metal pin and said first and second matching circuit portions to select one of said first and second matching circuits for operation with said antenna coupler, said switch circuit coupling said metal pin to said first matching circuit portion for operation of the communication device in said first frequency band and coupling said metal pin to said second matching circuit portion for operation of the communication device in said second frequency band.

10. The antenna coupler of claim 1 wherein said antenna coupler comprises a helical wire for surrounding at least a portion of the communication device antenna when the communication device is operable with the coupling device.

11. An antenna coupling device for coupling radio frequency signals from a communication device having an internal antenna and at least one externally accessible ground point, the communication device operable in two frequency bands, the antenna coupler comprising:

a connector coupleable to an external antenna;

a ground plane having an upper surface and sized to match the communication device;

an antenna coupler mounted on said ground plane upper surface, for coupling radio signals between the communication device antenna and said external antenna connector;

at least one ground pin, coupled to said upper surface of said ground plane, for contacting the externally accessible ground point; and

a matching circuit coupled to said antenna coupler to receive the radio frequency signals and to generate a predetermined impedance to match said antenna coupler to the communication device antenna and said external antenna connector at each of the first frequency band and the second frequency band.

12. The coupling device of claim 11 wherein said ground plane includes first and second abutting vertical portions mounted on said upper surface, said first and second abutting vertical portions being positioned in a substantially orthogonal relation to each other and to said ground plane upper surface.

13. The coupling device of claim 11, further including an external amplifier operationally coupled between said matching circuit and said external antenna connector to amplify signals between the communication device antenna and said external antenna connector.

14. The coupling device of claim 11 wherein said antenna coupler comprises a plurality of upward facing curved metal bands, a first of said metal bands being

electrically isolated from said ground plane to couple radio signals between the communication device antenna and said external antenna when the communications device is operating in the first frequency band, a second of said metal bands being electrically isolated from said ground plane to couple radio signals between the communication device antenna and said external antenna when the communications device is operating in the second frequency band, and a third of said metal bands being electrically coupled to said ground plane.

15. The coupling device of claim 14 wherein said matching circuit comprises a first matching circuit having an input terminal to match the communication device antenna when the communications device is operating in said first frequency band and a second matching circuit having an input terminal to match the communication device antenna when the communications device is operating in said second frequency band, said first matching circuit input terminal being coupled to said first metal band, said second matching circuit input terminal being coupled to said second metal band.

16. The coupling device of claim 11 wherein said antenna coupler comprises a metal pin sized to permit physical contact with the communication device antenna when the communication device is operable with the coupling device.

17. The coupling device of claim 16 wherein said matching circuit is a dual-band matching circuit coupled to said antenna coupler to generate a predetermined impedance to substantially match said antenna coupler to the communication device antenna at each of the first frequency band and the second frequency band.

18. The coupling device of claim 16 wherein said matching circuit comprises a first matching circuit for operation of the communication device in the first frequency band and a second matching circuit for operation of the communication device in the second frequency band, the coupling device further including a switch circuit coupled between said metal pin and said first and second matching circuits to select one of said first and second matching circuits for operation with said antenna coupler, said switch circuit coupling said metal pin to said first matching for operation of the communication device in said first frequency band and coupling said metal pin to said second matching for operation of the communication device in said second frequency band.

19. The antenna coupler of claim 11 wherein said antenna coupler comprises a helical wire for surrounding at least a portion of the communication device antenna when the communication device is operable with the coupling device.

20. The coupling device of claim 11 wherein said matching circuit has first and second output terminals for operation of the communication device in the first frequency band and the second frequency band, respectively, the coupler further including a selection circuit coupled to said first and second output terminals to couple a selected one of said first and second output terminals to a device output terminal with said first output terminal being selected for operation of the communication device in the first frequency band and said second output terminal being selected for operation of the communication device in the second frequency band.

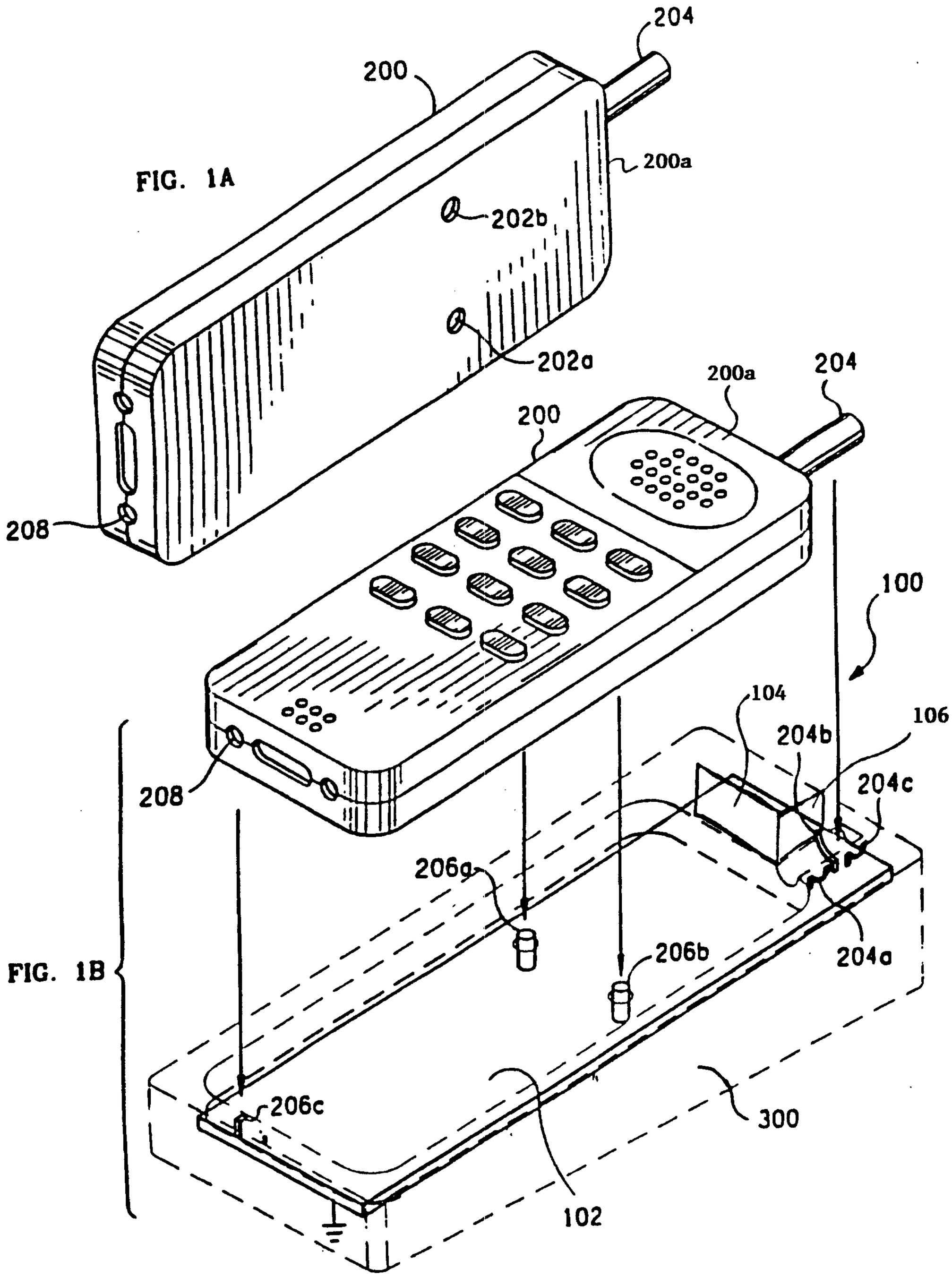

204
200
200a
202b
202a
208
200a
204
200
208
100
104
106
204b
204c
206a
206b
204a
206c
300
102

FIG. 1A

FIG. 1B

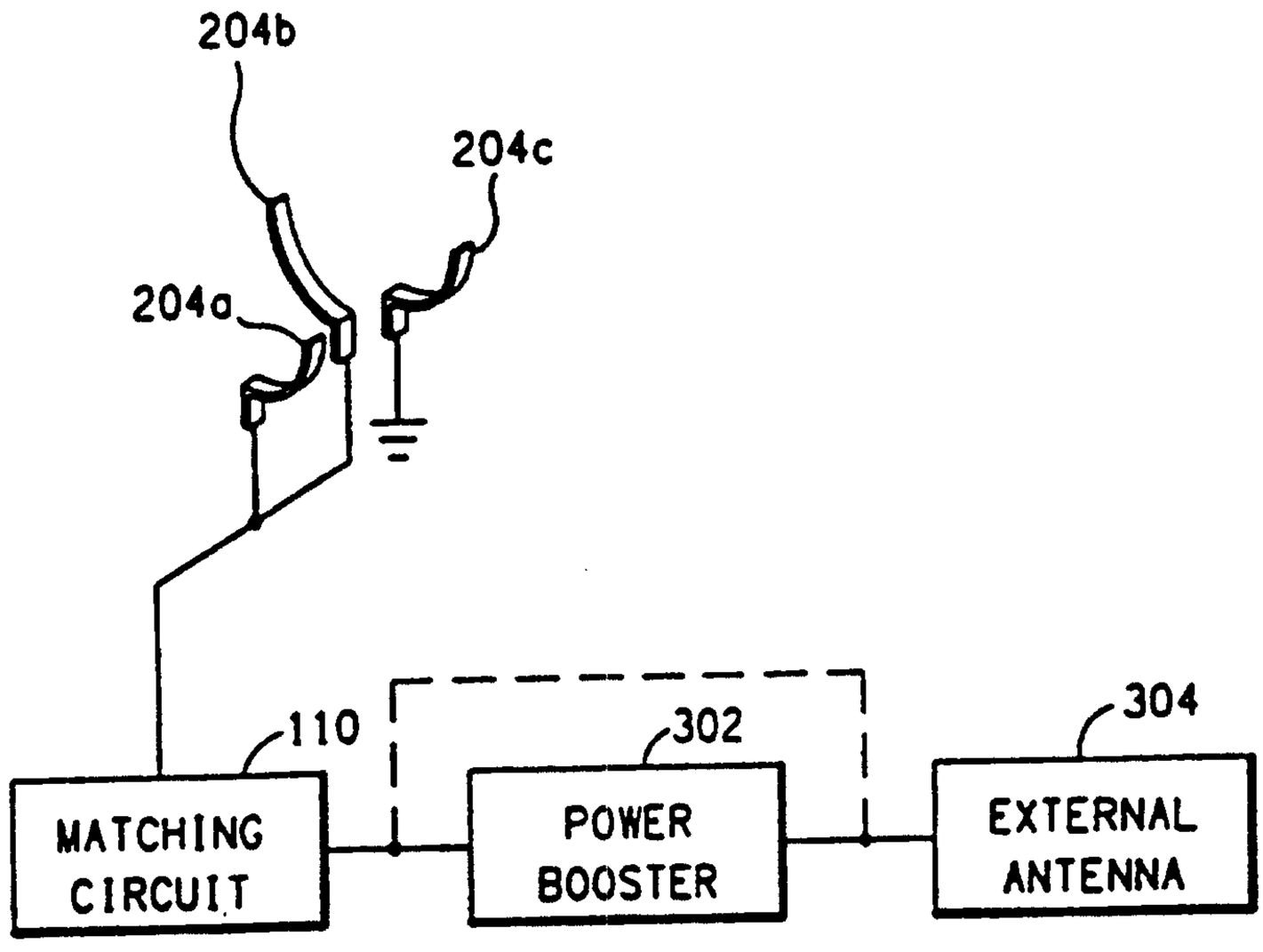

204b
204c
204a
110
302
304
MATCHING CIRCUIT
POWER BOOSTER
EXTERNAL ANTENNA

FIG. 2A

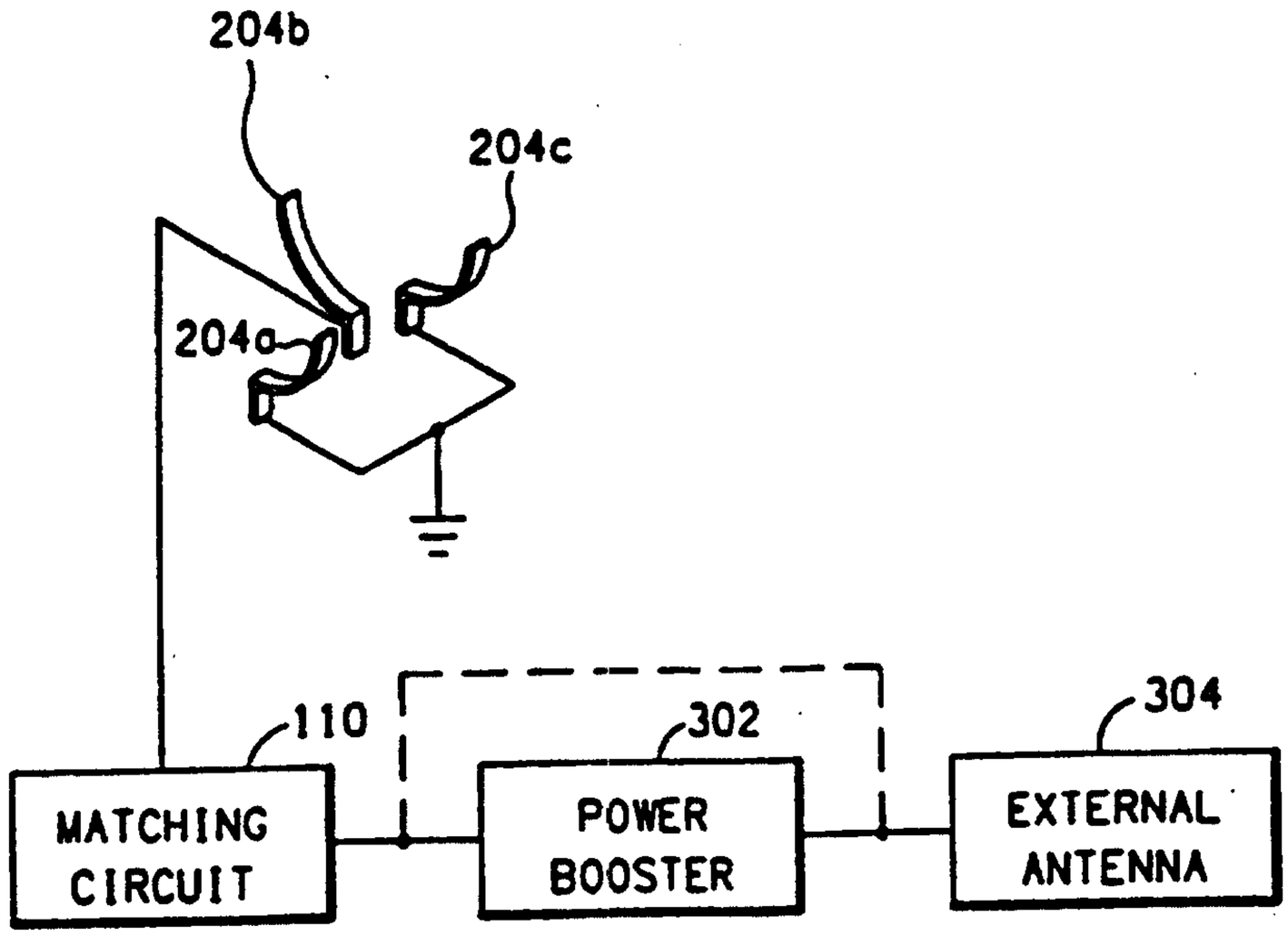

204b
204c
204a
110
302
304
MATCHING CIRCUIT
POWER BOOSTER
EXTERNAL ANTENNA

FIG. 2B

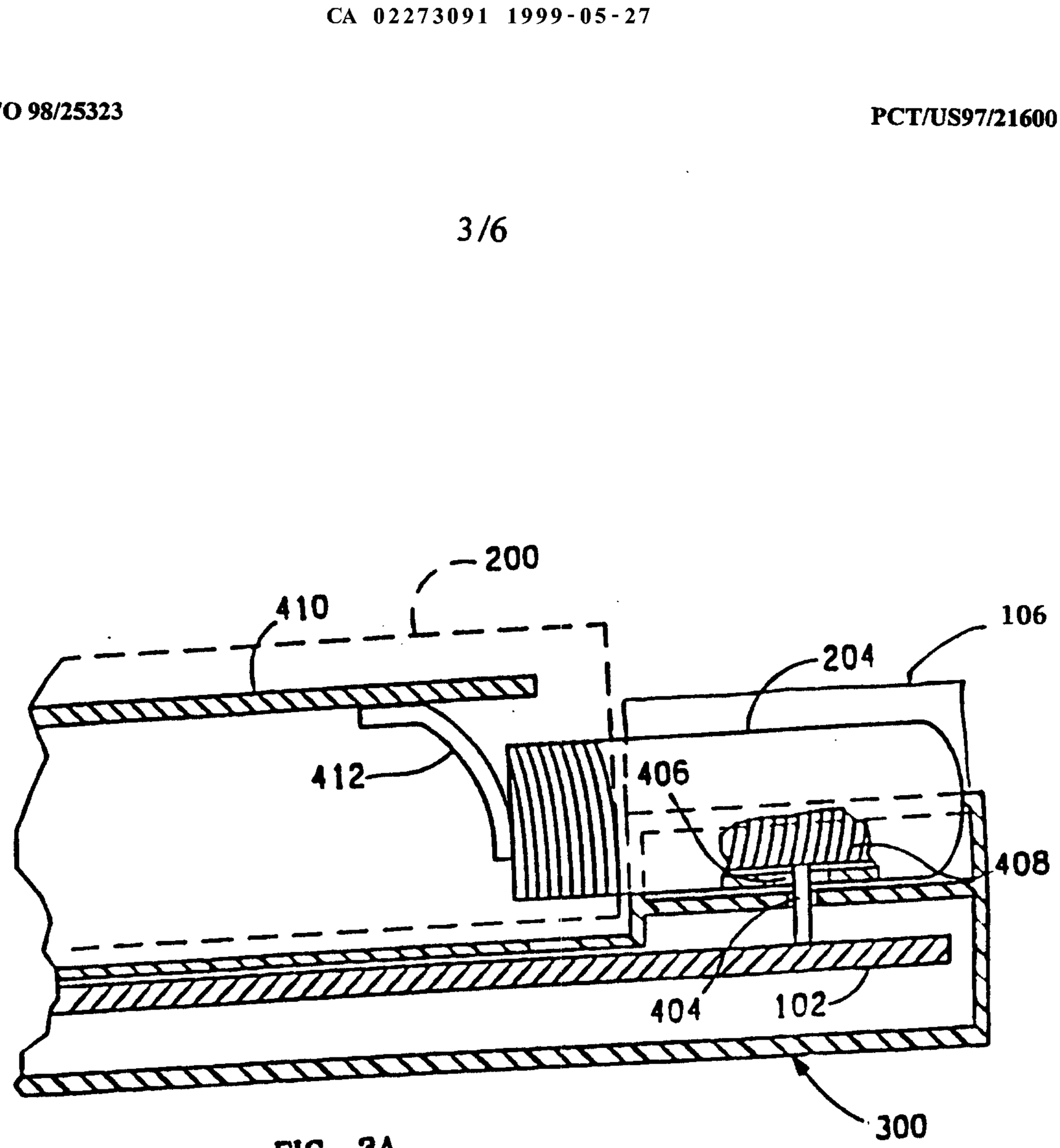

200
410
106
204
412
406
408
404
102
300

FIG. 3A

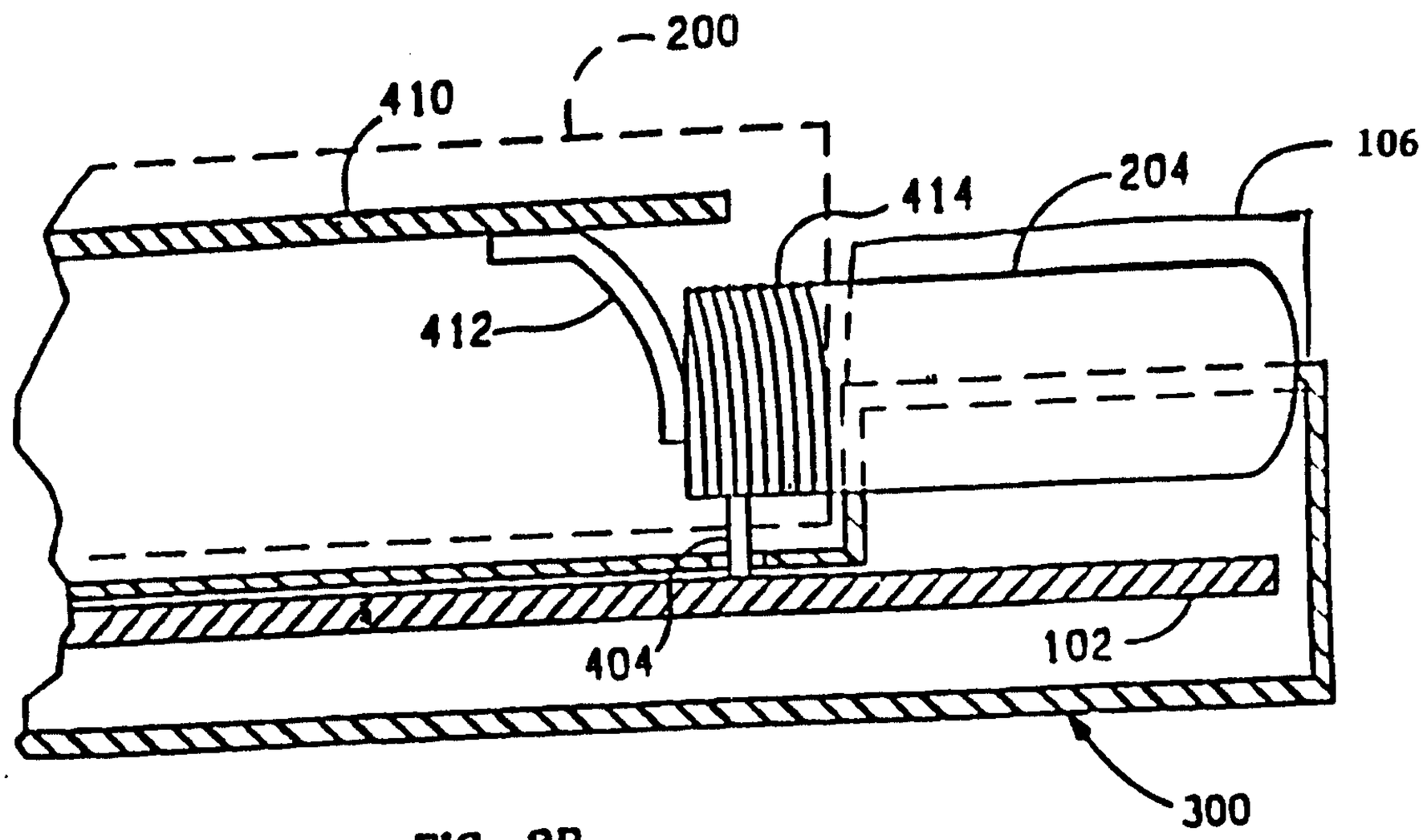

200
410
106
414
204
412
404
102
300

FIG. 3B

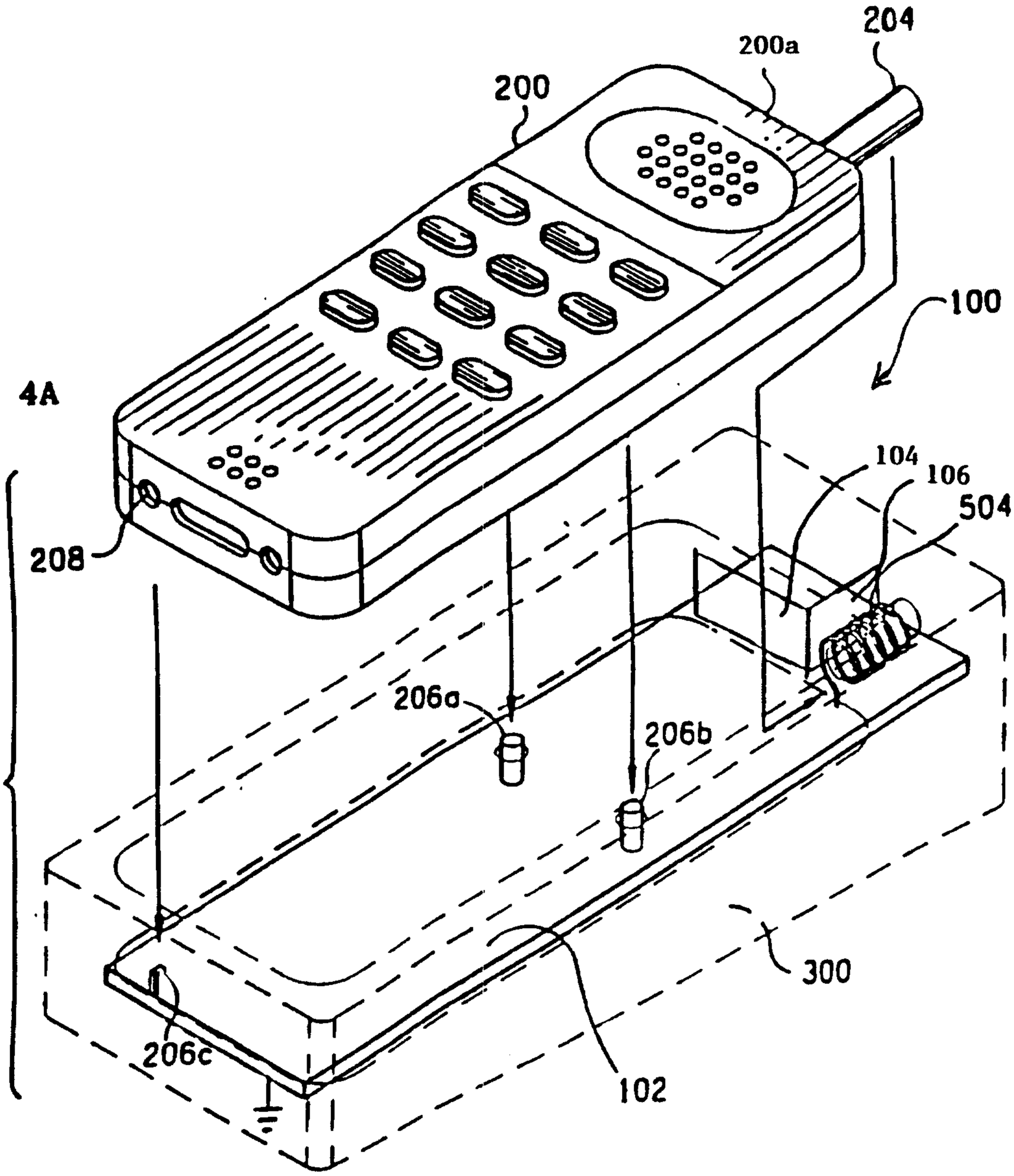

204
200a
200
100
104
106
504
208
206a
206b
206c
102
300

FIG. 4A

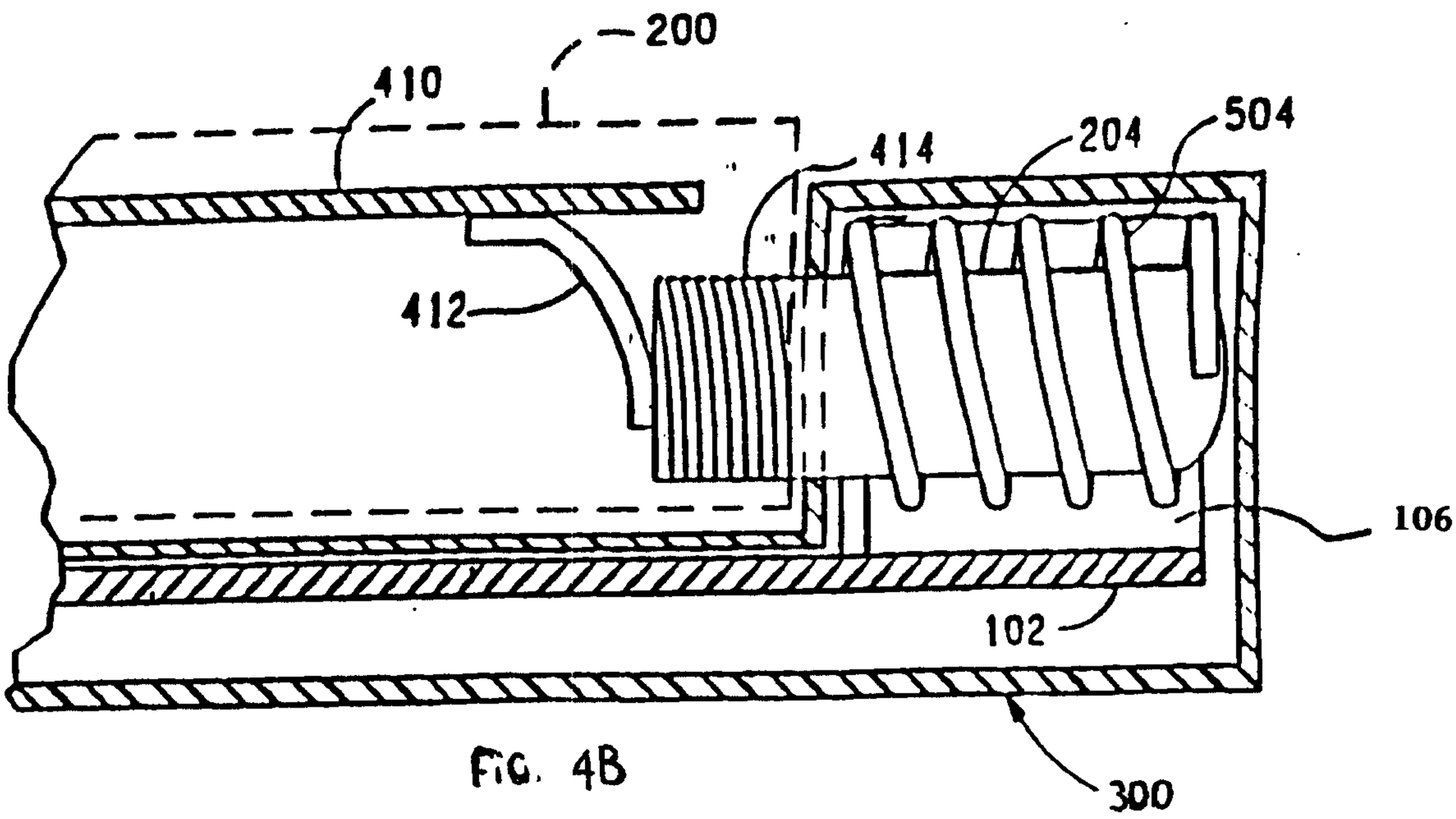

200
410
414
204
504
412
106
102
300

Fig. 4B

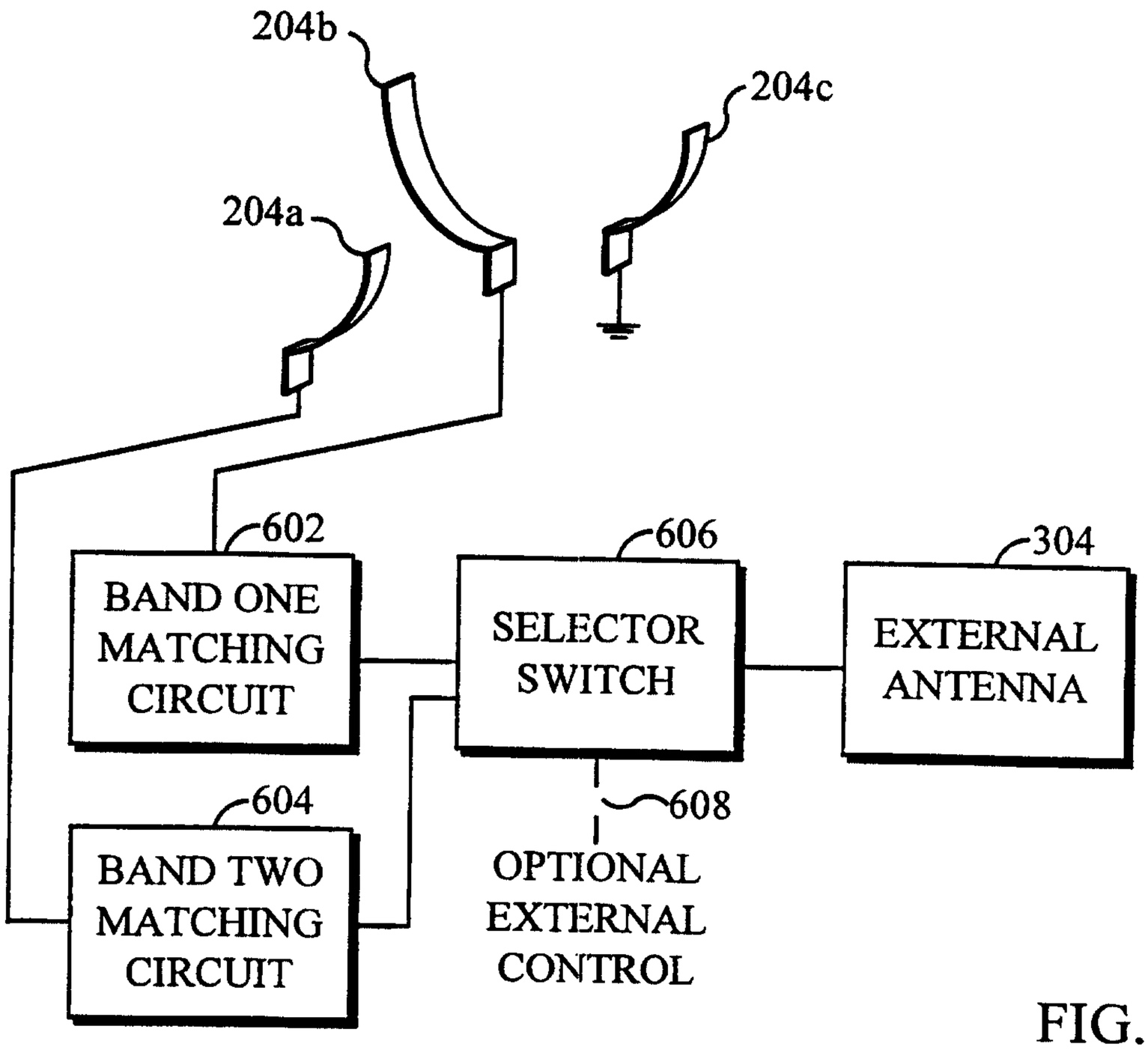

204b
204c
204a
602
606
304
BAND ONE MATCHING CIRCUIT
SELECTOR SWITCH
EXTERNAL ANTENNA
604
608
BAND TWO MATCHING CIRCUIT
OPTIONAL EXTERNAL CONTROL

FIG. 5A

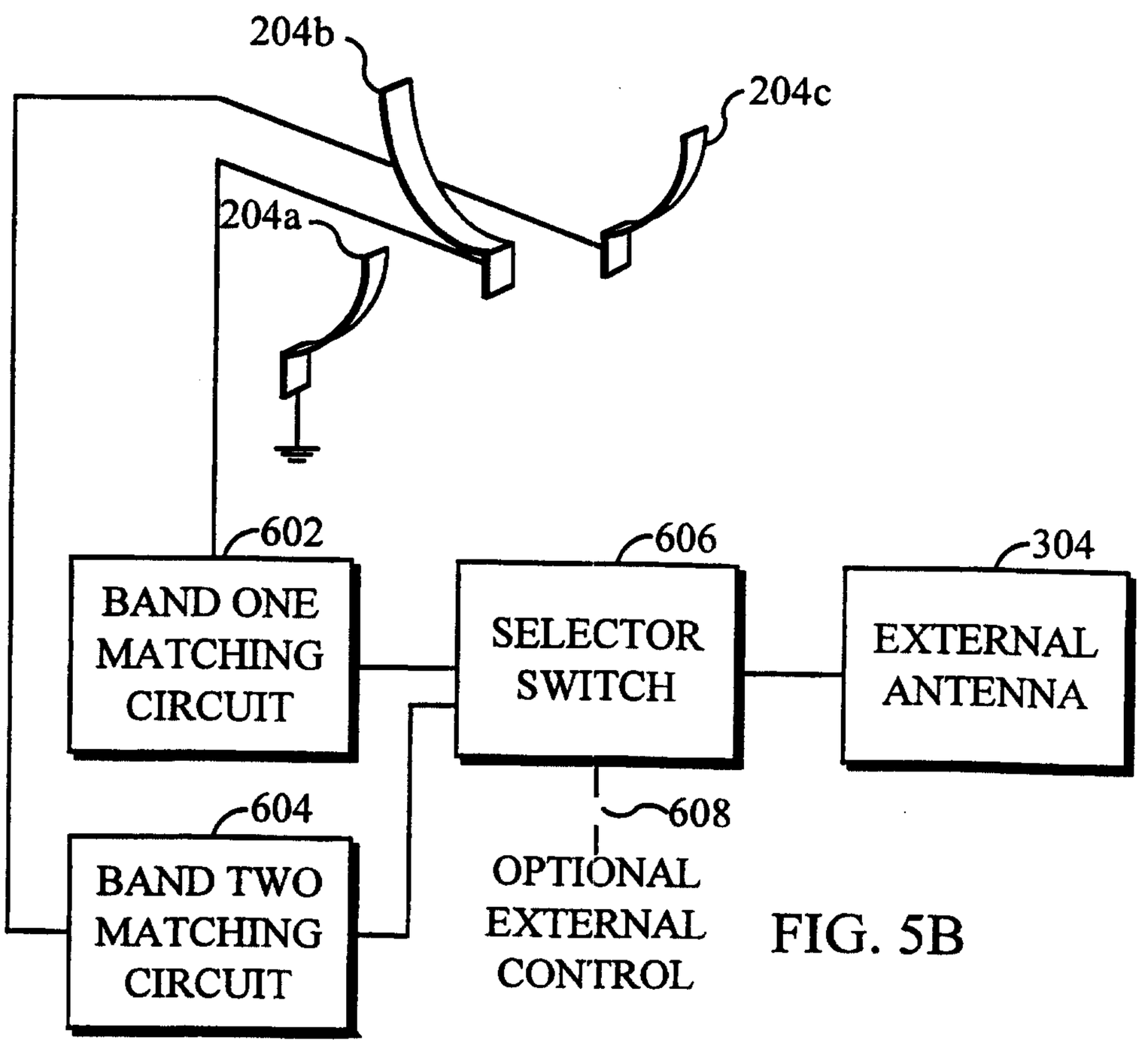

204b
204c
204a
602
606
304
BAND ONE MATCHING CIRCUIT
SELECTOR SWITCH
EXTERNAL ANTENNA
604
608
BAND TWO MATCHING CIRCUIT
OPTIONAL EXTERNAL CONTROL

FIG. 5B

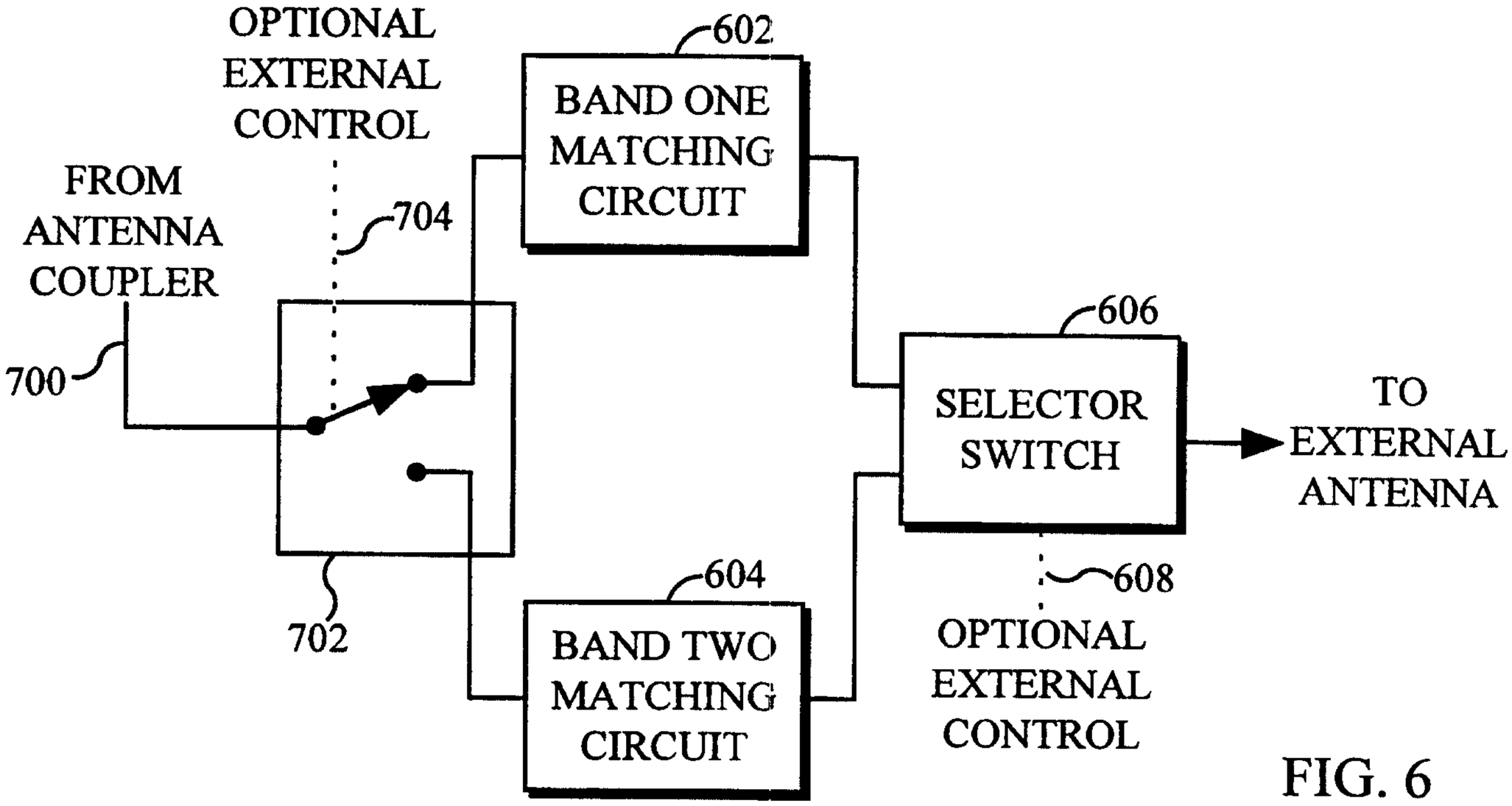

OPTIONAL
EXTERNAL
CONTROL
602
BAND ONE
MATCHING
CIRCUIT
FROM
ANTENNA
COUPLER
704
700
606
SELECTOR
SWITCH
TO
EXTERNAL
ANTENNA
604
608
BAND TWO
MATCHING
CIRCUIT
OPTIONAL
EXTERNAL
CONTROL
702

FIG. 6

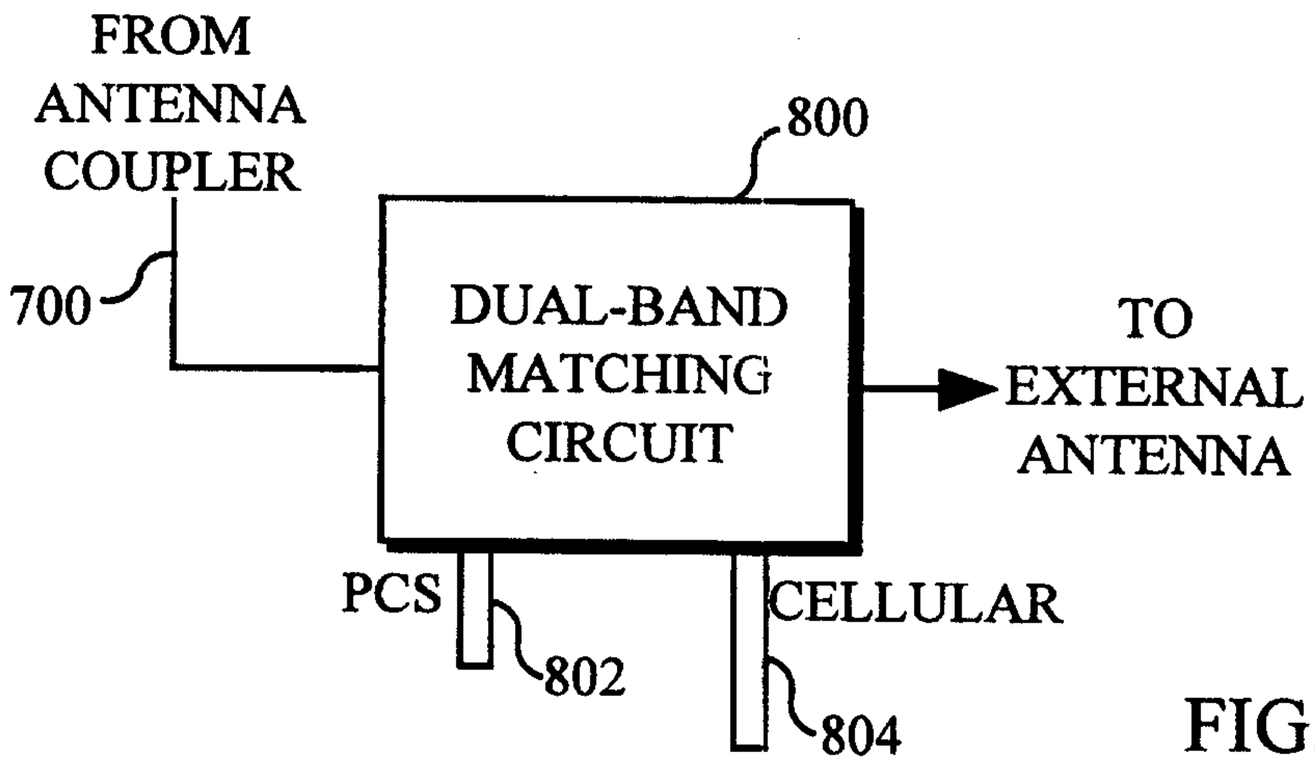
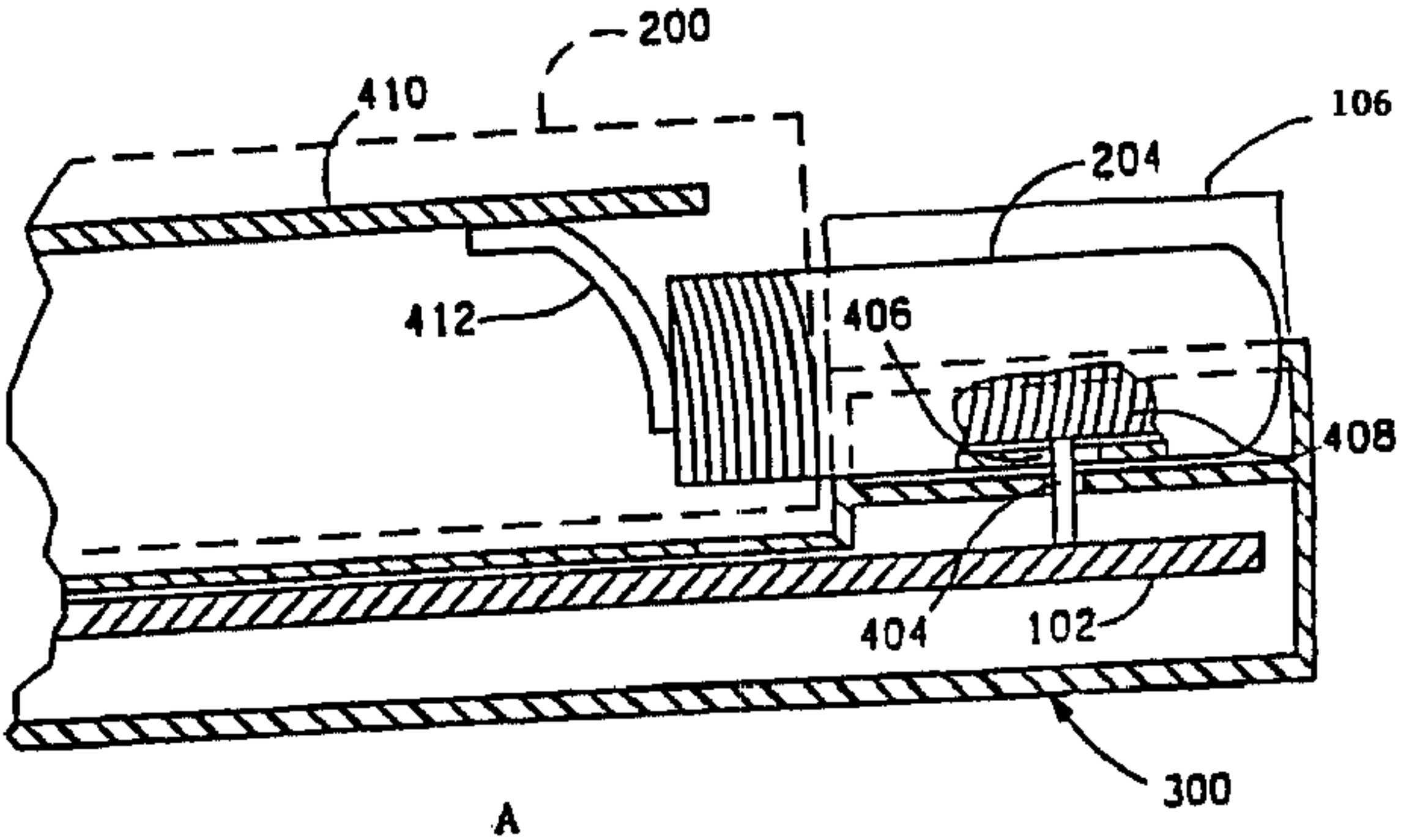
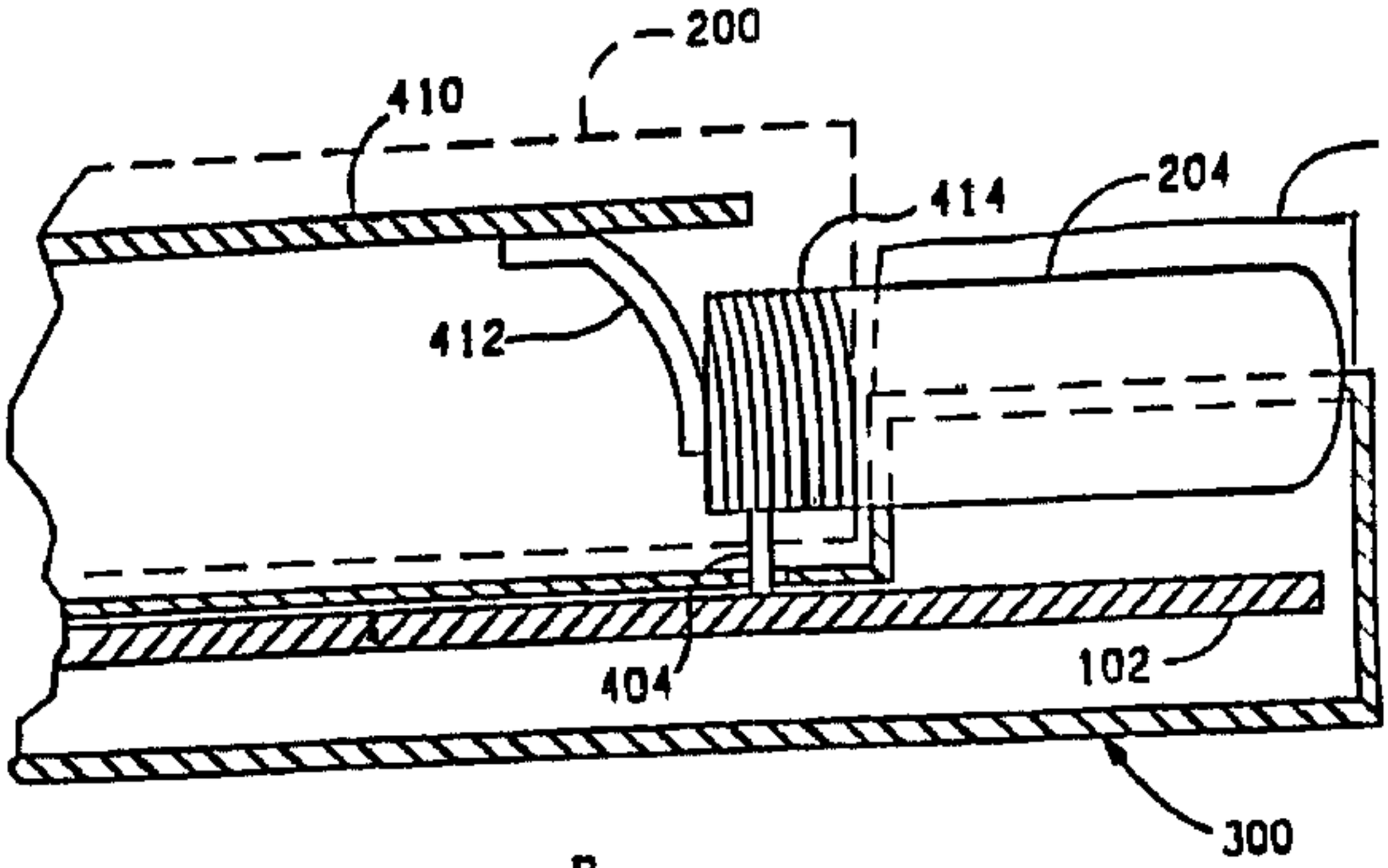

FROM
ANTENNA
COUPLER
800
700
DUAL-BAND
MATCHING
CIRCUIT
TO
EXTERNAL
ANTENNA
PCS
CELLULAR
802
804

FIG. 7


200
410
106
204
412
406
408
404
102
300

A


200
410
106
204
414
412
404
102
300

B