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(54) **REMOTE EXPLOSION DETONATION SYSTEM**

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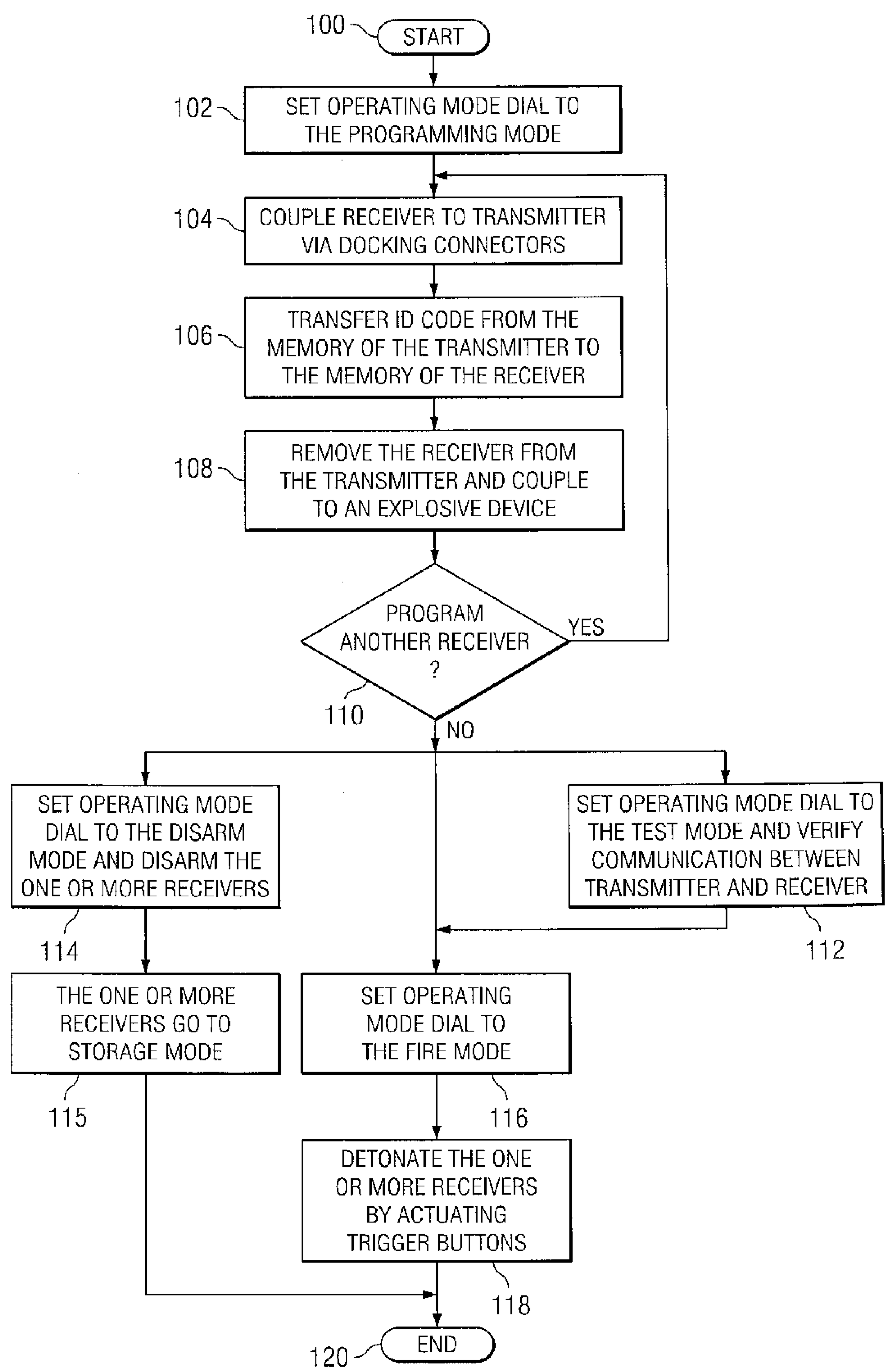
(57) **ABSTRACT**

According to one embodiment of the disclosure, a remote explosive detonation system includes a transmitter and at least one receiver having a detonator. The transmitter transmits an electro-magnetic signal having a transmitter identification code that may be received by the receiver. The receiver initiates the detonator if the transmitter identification code matches an internal identification code stored in the receiver.



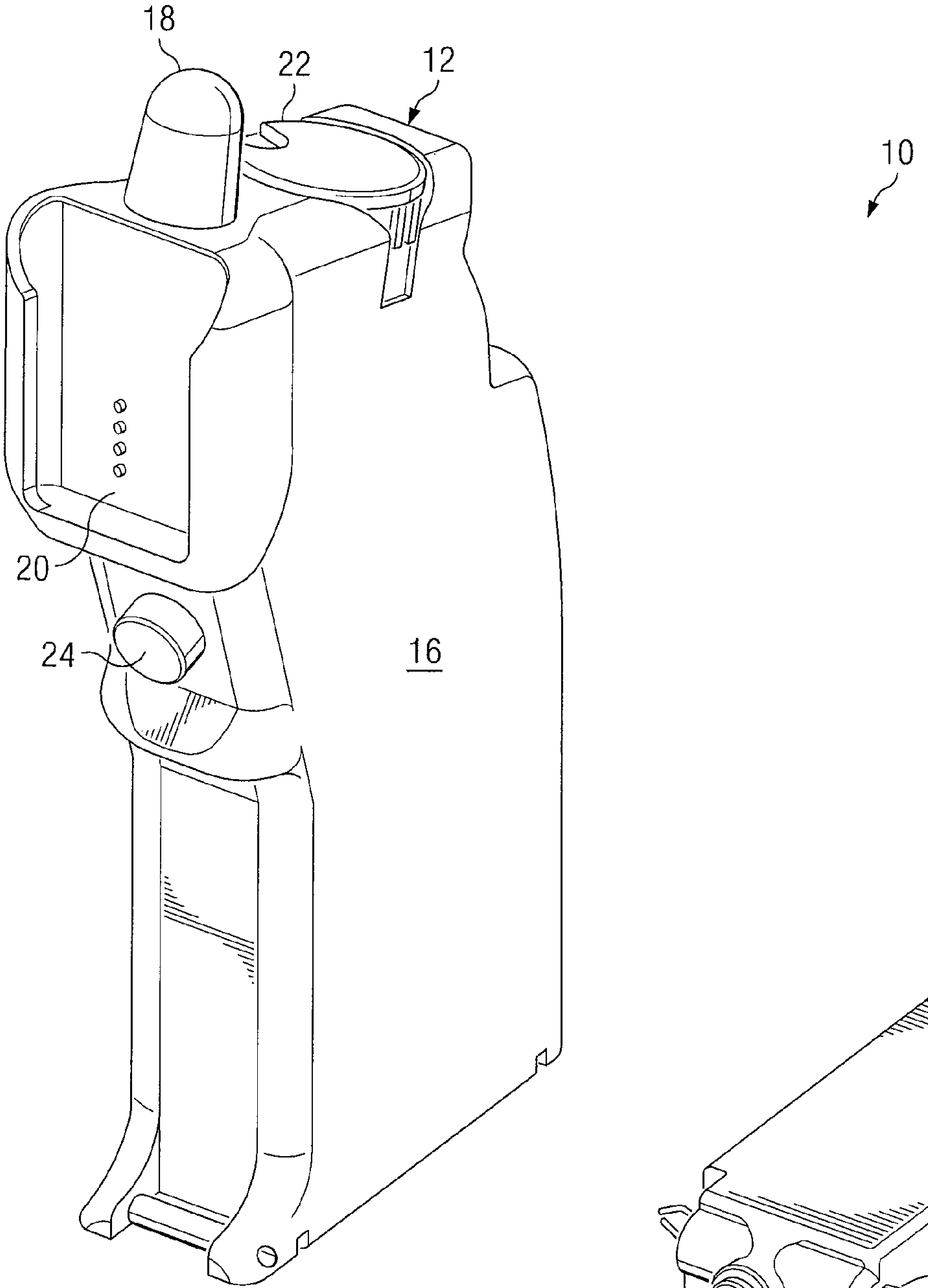


FIG. 1A

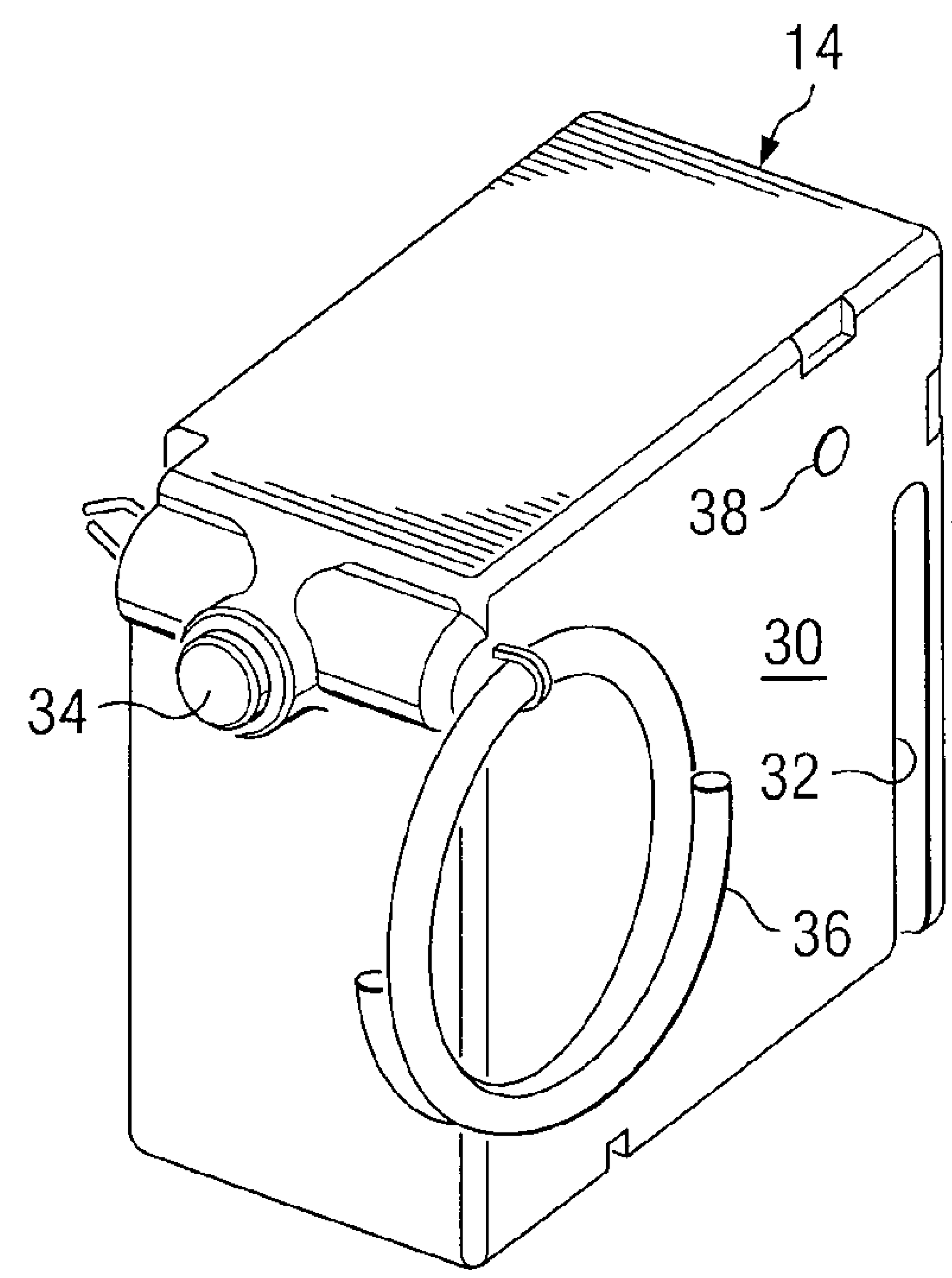


FIG. 2A

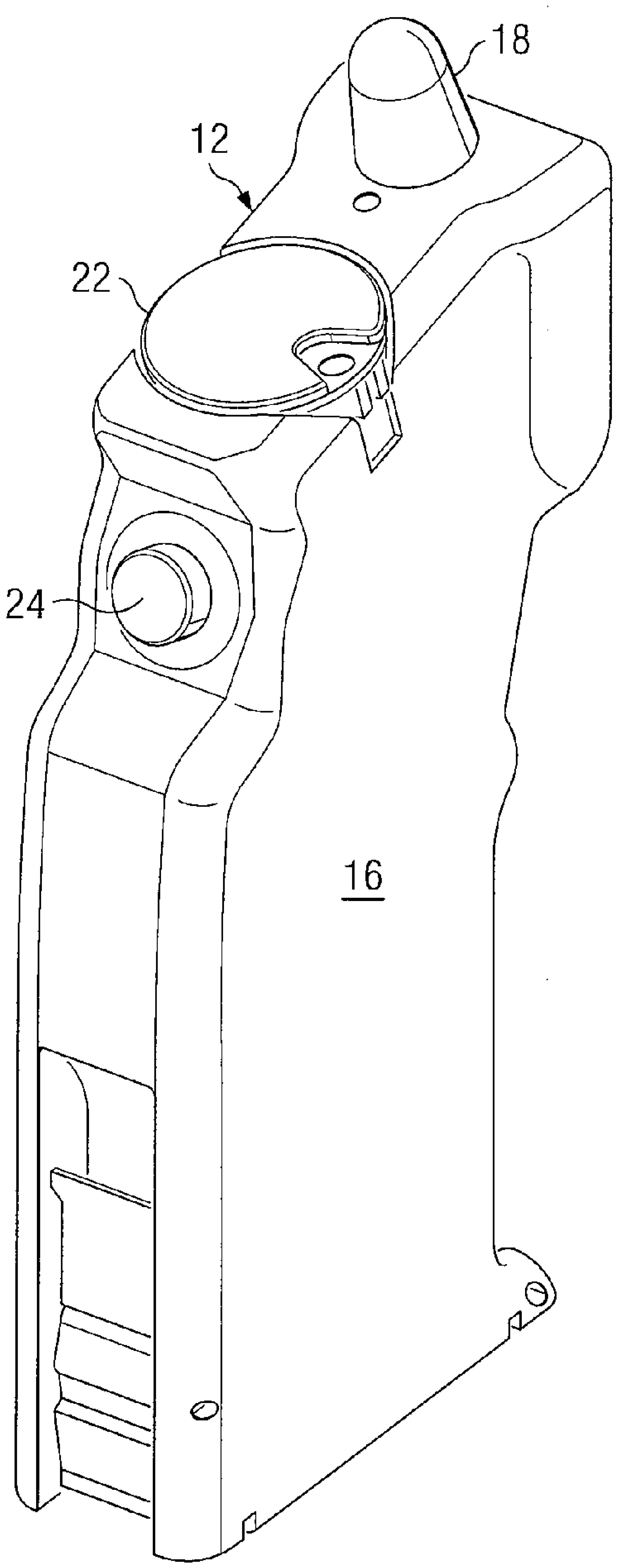


FIG. 1B

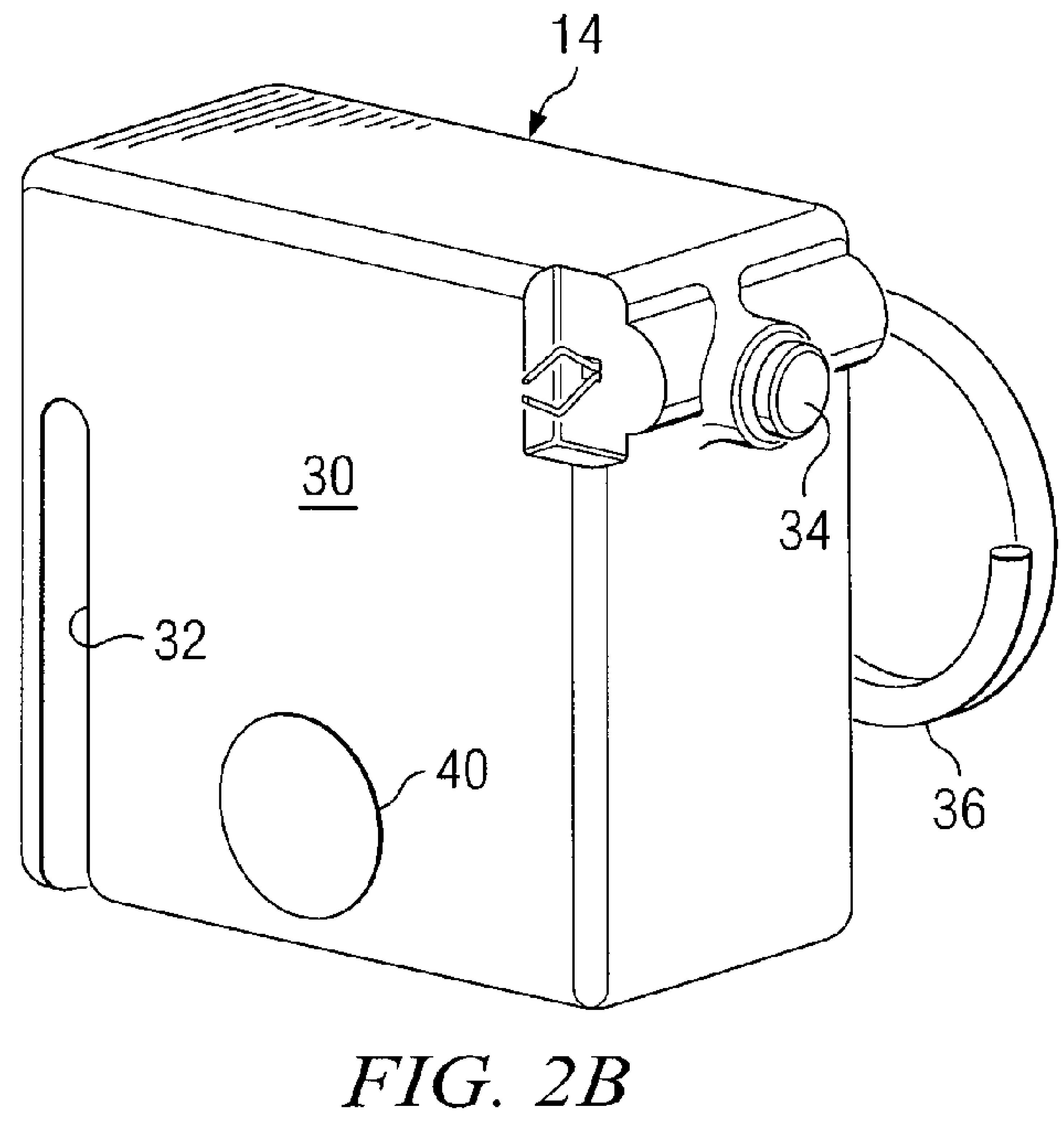


FIG. 2B

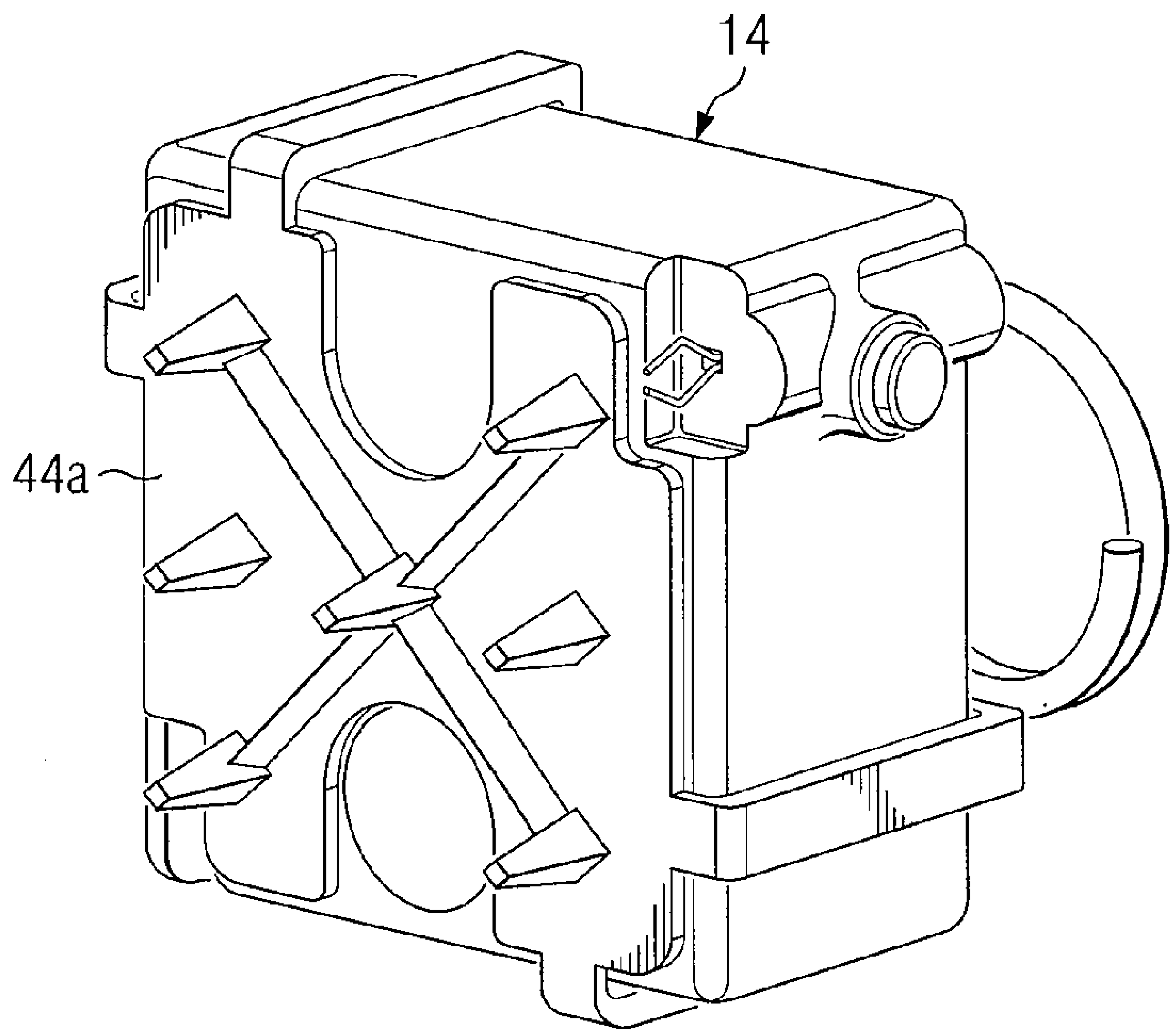


FIG. 3A

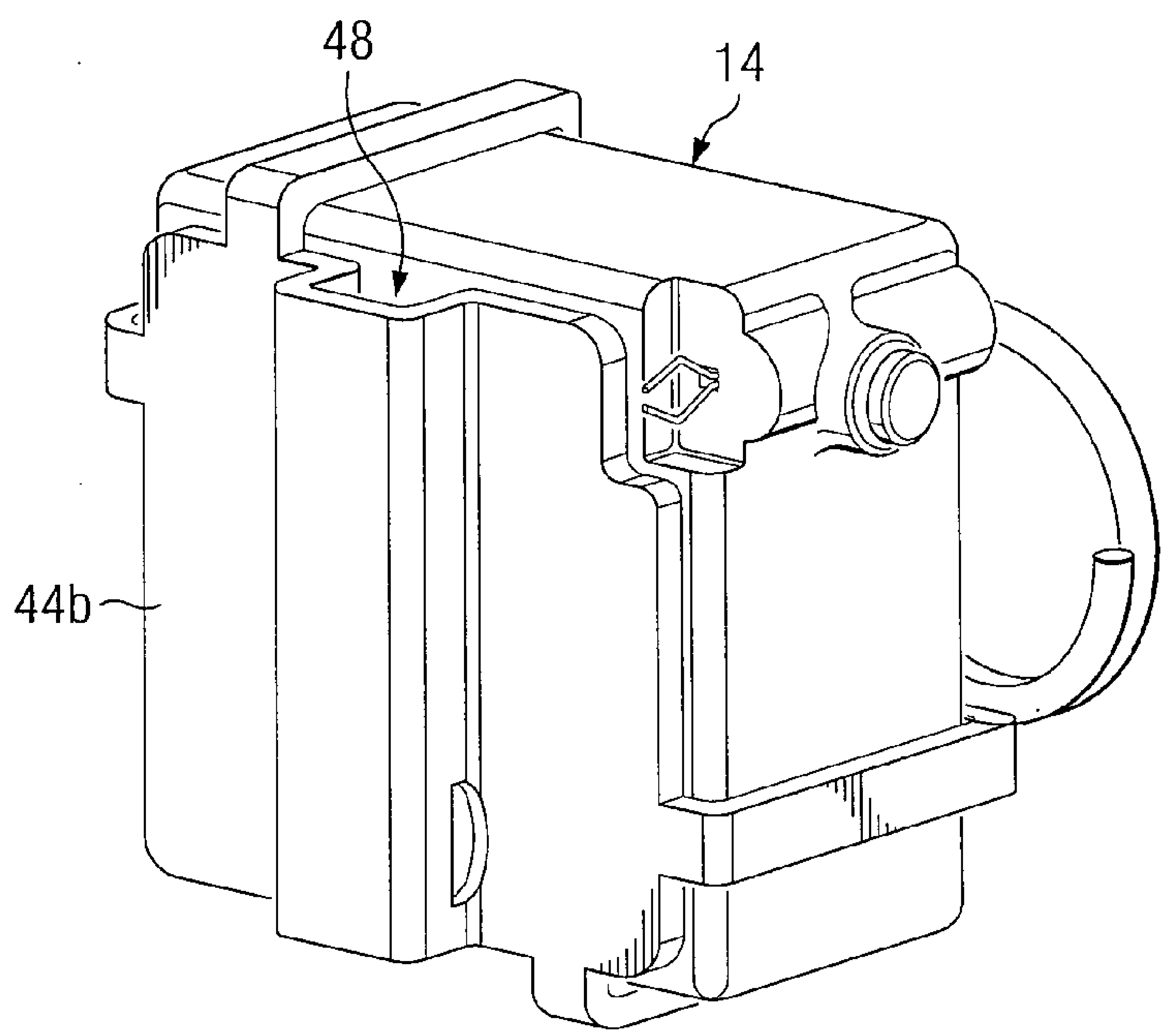


FIG. 3B

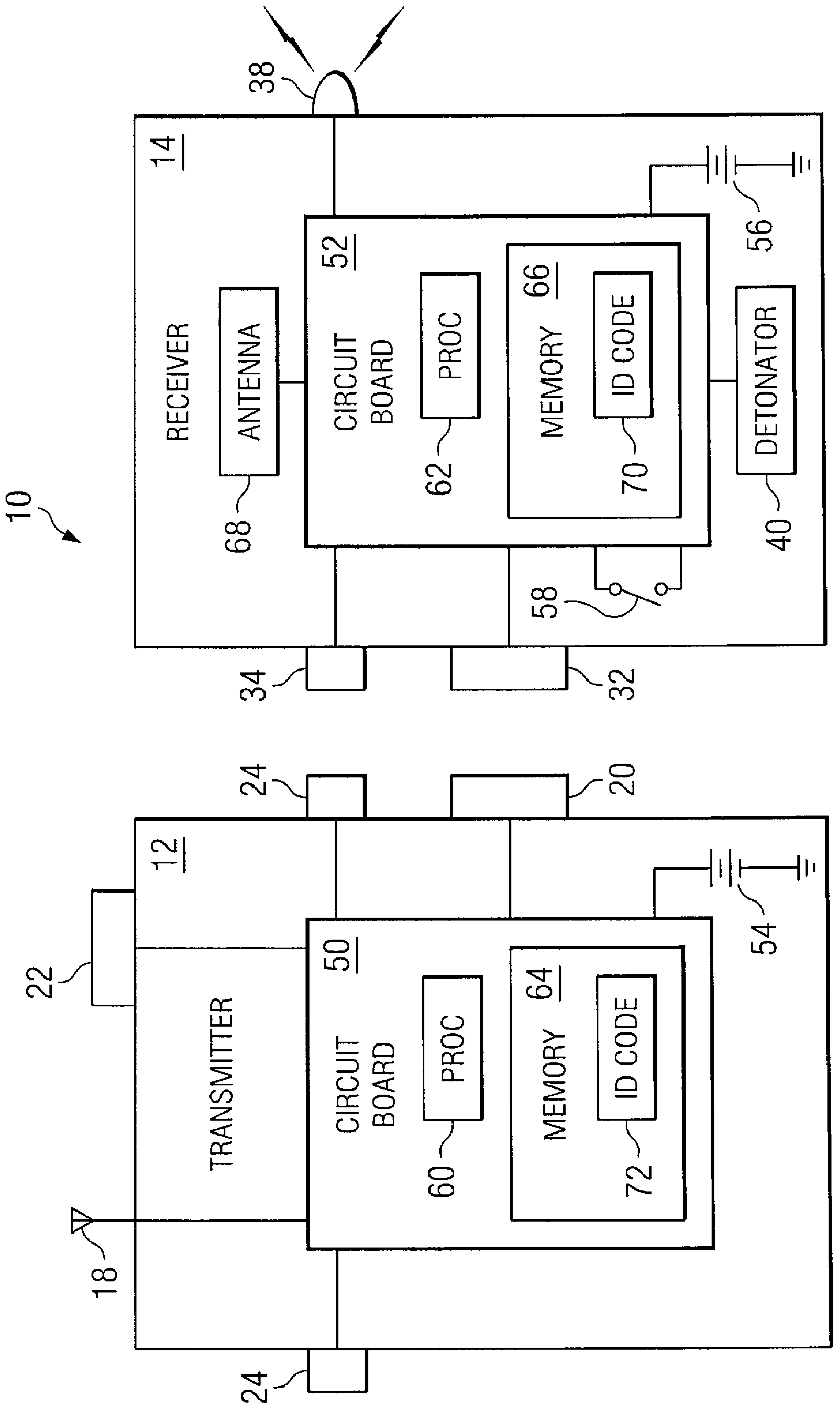

10
RECEIVER
14
ANTENNA
68
CIRCUIT BOARD
52
PROC
62
MEMORY
66
ID CODE
70
DETONATOR
40
38
56
58
34
32
TRANSMITTER
12
CIRCUIT BOARD
50
PROC
60
MEMORY
64
ID CODE
72
18
22
24
20
54

FIG. 4

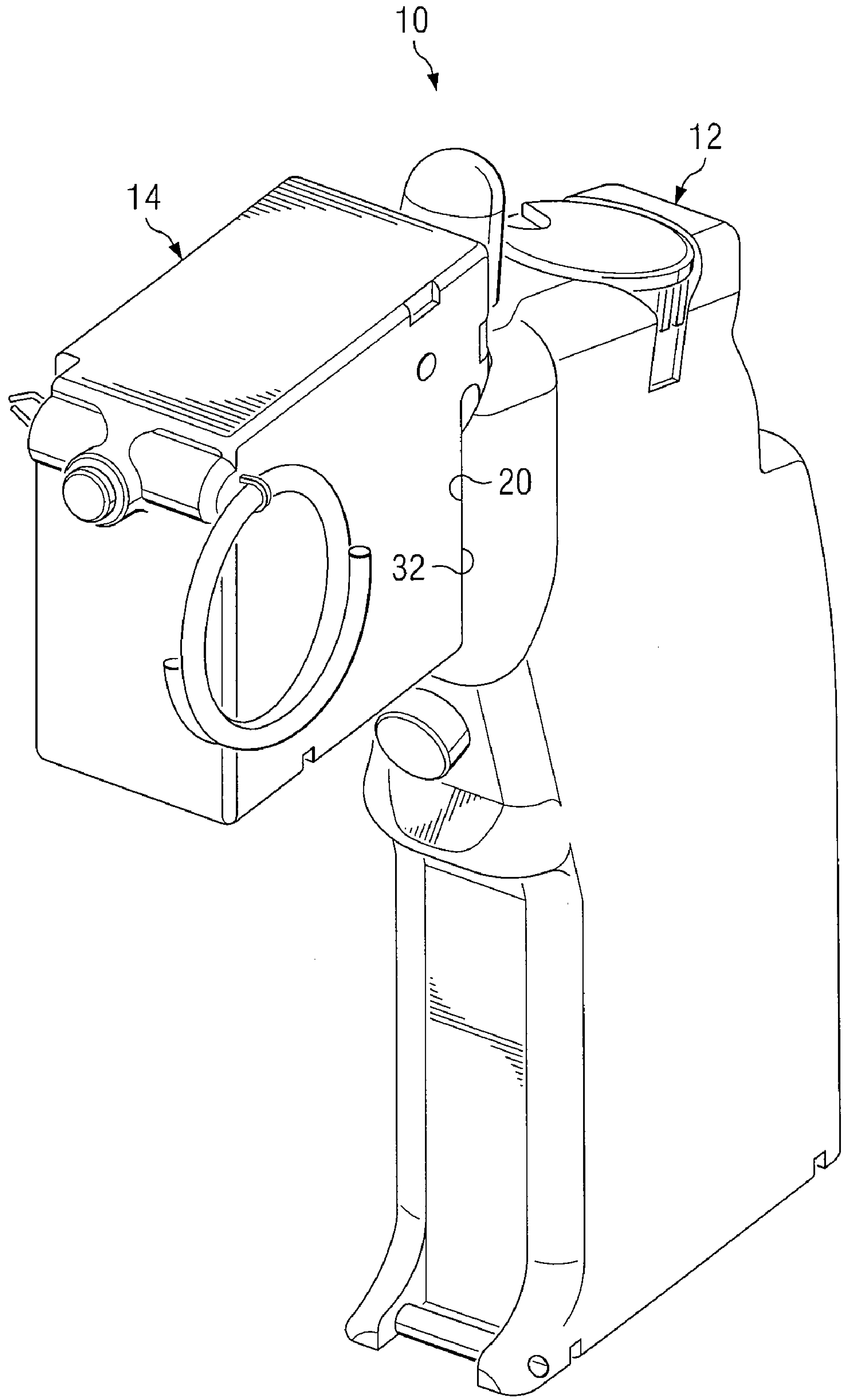


FIG. 5

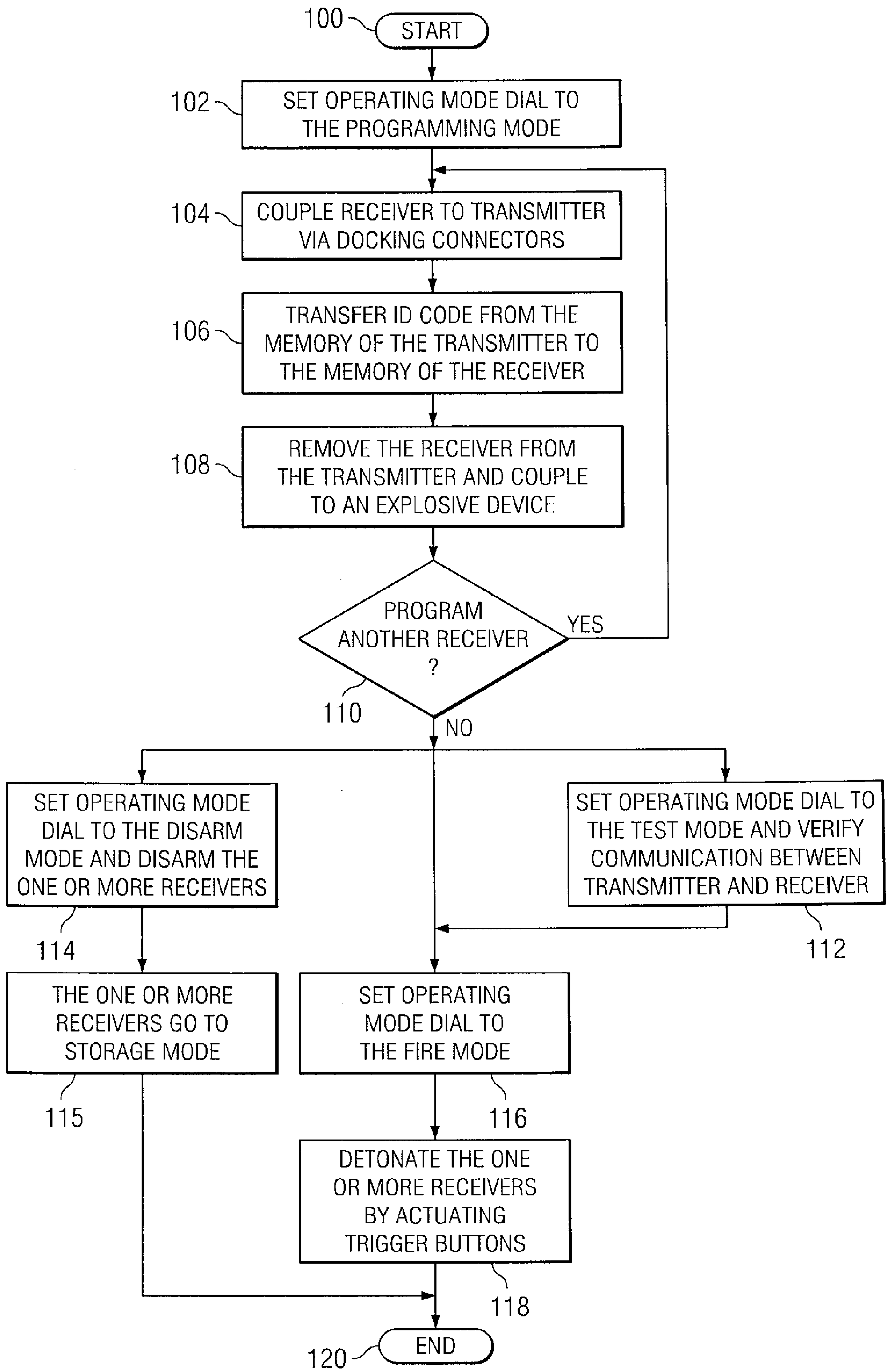

100
START
102
SET OPERATING MODE DIAL TO THE PROGRAMMING MODE
104
COUPLE RECEIVER TO TRANSMITTER VIA DOCKING CONNECTORS
106
TRANSFER ID CODE FROM THE MEMORY OF THE TRANSMITTER TO THE MEMORY OF THE RECEIVER
108
REMOVE THE RECEIVER FROM THE TRANSMITTER AND COUPLE TO AN EXPLOSIVE DEVICE
PROGRAM ANOTHER RECEIVER ?
YES
110
NO
SET OPERATING MODE DIAL TO THE DISARM MODE AND DISARM THE ONE OR MORE RECEIVERS
114
SET OPERATING MODE DIAL TO THE TEST MODE AND VERIFY COMMUNICATION BETWEEN TRANSMITTER AND RECEIVER
112
THE ONE OR MORE RECEIVERS GO TO STORAGE MODE
115
SET OPERATING MODE DIAL TO THE FIRE MODE
116
DETONATE THE ONE OR MORE RECEIVERS BY ACTUATING TRIGGER BUTTONS
118
120
END

FIG. 6

REMOTE EXPLOSION DETONATION SYSTEM

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application Ser. No. 61/002,476, entitled "REMOTE DETONATION SYSTEM," which was filed on Nov. 9, 2007.

TECHNICAL FIELD OF THE DISCLOSURE

[0002] This disclosure generally relates to explosives, and more particularly, to a remote explosive detonation system for explosives and a method of operating the same.

BACKGROUND OF THE DISCLOSURE

[0003] Explosives used in military combat may be initiated by detonation devices. Due to the destructive nature of explosives, these detonation devices may incorporate various safety features to avoid premature detonation. For example, a shock tube is a type of detonation device that transmits a detonation signal to a remotely located explosive using a pressure signal. The shock tube may be made of non-conductive materials, which are not generally susceptible to premature detonation caused by stray electro-magnetic radiation.

SUMMARY OF THE DISCLOSURE

[0004] According to one embodiment of the disclosure, a remote explosive detonation system includes a transmitter and at least one receiver configured with a detonator. The transmitter transmits an electro-magnetic signal with a transmitter identification code that may be received by the receiver. The receiver initiates the detonator if the transmitter identification code matches an internal identification code stored in the receiver.

[0005] Some embodiments of the disclosure may provide numerous technical advantages. For example, one embodiment of the remote explosive detonation system may provide a relatively reliable approach for remotely detonating explosives that reduces detection of the source of the detonation. Known detonation systems use elongated shock tubes that convey a detonation signal using an impulse blast of pressurized air. These shock tubes, however, often leave a residual trail indicating the source of the explosive blast, which may compromise the security of personnel using the explosives. The remote explosive detonation system of the present disclosure uses a wireless signal that may be substantially difficult to trace following detonation, thus alleviating security issues associated with enemy response following use of remotely configured explosives. The remote explosive detonation system may be relatively quicker to implement than known detonation systems that require spooling shock tube from the explosive to its initiation point. Additionally, the location of the initiation point may be concealed more effectively then known explosive detonation systems using shock tubes that may leave a residual trail of shock tube material following detonation of the explosive

[0006] Other technical advantages will be readily apparent to one of ordinary skill in the art from the following figures, descriptions, and claims. Moreover, while specific advantages have been enumerated above, various embodiments may include all, some, or none of the enumerated advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] A more complete understanding of embodiments of the disclosure will be apparent from the detailed description taken in conjunction with the accompanying drawings in which:

[0008] FIGS. **1**A and **1**B are front perspective and rear perspective views, respectively, of one embodiment of a transmitter of the remote explosive detonation system according to the teachings of the present disclosure;

[0009] FIGS. **2**A and **2**B are front perspective and rear perspective views, respectively, of one embodiment of a receiver that may be used with the transmitter of FIGS. **1**A and **1**B;

[0010] FIG. **3**A is a perspective view of one embodiment of a claw accessory clip that may be configured on the receiver of FIGS. **2**A and **2**B;

[0011] FIG. **3**B is a perspective view of one embodiment of a shock tube accessory clip that may be configured on the receiver of FIGS. **2**A and **2**B;

[0012] FIG. **4** is a diagram view of remote explosive detonation system showing several elements of the transmitter and the receiver;

[0013] FIG. **5** is a perspective view showing the receiver of FIGS. **2**A and **2**B docked on the transmitter of FIGS. **1**A and **1**B; and

[0014] FIG. **6** is a flowchart showing a series of actions that may be performed by the remote explosive detonation system to remotely detonate an explosive.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0015] A shock tube is a detonation device that may be used to detonate an explosive, such as cyclotrimethylene trinitramine (C4). These shock tubes, however, may have drawbacks. For example, following detonation of the explosive, a shock tube may leave a residual trail indicating the location of the triggering device.

[0016] FIGS. **1**A through **2**B show one embodiment of a remote explosive detonation system **10**. Remote explosive detonation system **10** generally includes a transmitter **12** and at least one receiver **14**. The transmitter **12** transmits an electro-magnetic signal that may be received by receiver **14** to detonate an explosive (not shown). As will be described in detail below, the transmitted electro-magnetic signal may include an identification code that may be used by the receiver **14** to ensure validity of the transmitted signal. Thus in some embodiments, remote explosive detonation system **10** may provide relatively secure remote explosive detonation of explosives without creating a residual trail as typically produced by shock tubes.

[0017] Transmitter **12** comprises a handheld transmitter housing **16** that is configured with an antenna **18**, transmitter docking connector **20**, an operating mode dial **22**, and one or more trigger buttons **24**. Transmitter housing **16** has a shape suitable for handling by the hand of a user. Transmitter **12** may have multiple independently operated actuation mechanisms that are simultaneously actuated for detonating the explosive. In this manner, the possibility of inadvertent detonation of the explosive may be reduced. In the particular embodiment shown, two trigger buttons **24** are implemented.

Other embodiments may include any suitable type and quantity of actuation mechanisms, such as two or more levers, or one button and one lever.

[0018] Receiver **14** comprises a receiver housing **30** that is configured with a receiver docking connector **32**, an arming button **34**, an arming/safety pin **36**, an indicator light **38**, and a detonator **40**. Receiver docking connector is engageable with transmitter docking connector **20**. In the particular embodiment shown, receiver housing **30** has outer dimensions of approximately 2.0 inches by 2.0 inches by 1.0 inches. In other embodiments, receiver housing **30** may have any suitable size.

[0019] Arming/safety pin **36** is removable from receiver housing **30**. Detonation is prevented when arming/safety pin **36** is engaged in receiver housing **30**. Once arming/safety pin **36** is removed, receiver **14** may be armed and ready to initiate detonation upon a valid signal from the transmitter **12**. Arming button **34** may be spring loaded such that removal of the arming/safety pin **36** allows the arming button **34** to project outwardly from the receiver housing **30**. The indicator light **38** may be any suitable source of light, such as a light emitting diode (LED) and may provide visual indication of the armed status of the receiver **14**. In one embodiment, the indicator light **38** emits only infrared light. In this manner, indicator light **38** may be visible only through night vision goggles.

[0020] Detonator **40** is configured to explode upon receipt of a valid signal from transmitter **12**. In one embodiment, detonator **40** includes only secondary explosive materials. That is, detonator **40** may be relatively free of any primary explosive material that may be susceptible to premature detonation. In one embodiment, detonator **40** is an exploding foil initiator (EFI), such as a low energy exploding foil initiator (LEEFI), that may be initiated by an electrical pulse of energy.

[0021] FIGS. **3**A and **3**B show two differing types of accessory clips **44***a* and **44***b* that may be configured on receiver housing **30**. Accessory clip **44***a* is a claw accessory clip having multiple claw-like protrusions **46** that may be impaled in explosives having a clay-like consistency, such as C4 explosive material. Accessory clip **44***b* is a shock tube accessory clip having an elongated cavity **48** for placement of a section of shock tube inside. Another embodiment of an accessory clip (not shown) may include a detonation cord accessory clip that provides coupling of the receiver **14** to a detonation cord.

[0022] FIG. **4** is a diagram view of remote explosive detonation system **10** showing several elements of transmitter **12** and receiver **14**. Transmitter **12** and receiver **14** each include a circuit board **50** and **52** that is powered by a battery **54** and **56**. Circuit board **50** of transmitter **12** is coupled to trigger buttons **24**, operating mode dial **22**, transmitter docking connector **20**, and antenna **18**. Circuit board **52** of receiver **14** is coupled to an arming/safety pin switch **58**, receiver docking connector **32**, arming button **34**, indicator light **38**, and detonator **40**, and an antenna **68**. In the particular embodiment shown, circuit boards **50** and **52** each include a processor **60** and **62** that executes instructions stored in a memory **64** and **66**. In other embodiments, circuit boards **50** and **52** may include any suitable form of logic for executing the various features of transmitter **12** and receiver **14**, respectively.

[0023] Transmitter **12** may include any suitable electrical circuit for generating a signal that is transmitted through antenna **18**. In one embodiment, transmitter **12** uses a spread spectrum signal transmission technique to transmit the signal, which may yield a low probability of intercept (LPI), a low probability of jamming (LPJ), and/or a low probability of spoofing (LPS). The spread spectrum signal transmission technique is a frequency hopping process in which the transmitted signal may be alternatively transmitted over differing frequencies. Because the transmitted electro-magnetic energy is spread over a relatively wide frequency range, the signal may be relatively difficult to jam, spoof, or intercept. In another embodiment, the frequency hopping process used to generate the spread spectrum signal may be proprietary to reduce unwanted reception of the transmitted signal from others. In another embodiment, the transmitter **12** and receiver **14** may use forward error correction (FEC) techniques to further reduce susceptibility to unwanted electro-magnetic radiation. In another embodiment, information may be transferred from transmitter **12** to receiver **14** using data packets. These data packets may be deciphered by receiver according to a preamble and/or a post-amble of the received data packet to verify proper receipt of signals from transmitter **12**. In another embodiment, receiver **14** may perform a hash function, such as a cyclic redundancy check (CRC) to verify proper receipt of signals from transmitter **12**. In another embodiment, transmitter **12** may transmit commands to receiver **14** using specific command words, such as logical words having greater than 65,000 combinations to reduce the possibility of misinterpretation of commands by receiver **14**.

[0024] The transmitter **12**/receiver **14** combination may have any suitable range that provides a relatively safe distance of transmitter **12** from receiver **14** when explosive is detonated. In a particular embodiment, an effective transmission range of greater than approximately 50 meters may provide sufficient protection from shrapnel or other debris caused by the detonation of explosives commonly used with remote explosive detonation system **10**.

[0025] Receiver **14** may include any suitable electrical circuit for receiving and processing the transmitted signal from transmitter **12**. Receiver **14** includes an antenna **68** that may be disposed within receiver housing for receiving the transmitted signal. In one embodiment, antenna **68** is a patch antenna. According to the teachings of the present disclosure, memory **66** of receiver **14** stores a receiver identification code **70** that may be compared with a transmitter identification code **72** that is modulated onto the signal transmitted by transmitter **12**. Only when transmitter identification code **72** matches receiver identification code **70** is detonation of detonator **40** allowed.

[0026] FIG. **5** shows the receiver **14** docked on the transmitter **12** by coupling the transmitter docking connector **20** with the receiver docking connector **32**. When receiver docking connector is coupled to transmitter docking connector **20**, receiver **14** may be programmed with the identification code from the transmitter **12**. In one embodiment, multiple receivers **14** may be programmed to detonate simultaneously in response to a single signal from transmitter **12**. To detonate multiple receivers **14** simultaneously, each of the multiple receivers **14** may be programmed to respond to transmitter **12** by sequentially docking each receiver **14** with transmitter **12**.

[0027] Modifications, additions, or omissions may be made to remote explosive detonation system **10** without departing from the scope of the disclosure. The components of remote explosive detonation system **10** may be integrated or separated. For example, The transmitter **12** may be implemented as a stand-alone device or may form a portion of another larger system. Moreover, the operations of remote explosive detonation system **10** may be performed by more, fewer, or other components. For example, the operations of transmitter **12** may generate an electro-magnetic signal that is relayed through a wireless repeater, such that receiver **14** receives the transmitted electro-magnetic signal from the wireless repeater. Additionally, operations of remote explosive detonation system **10** may be performed using any suitable logic comprising software, hardware, and/or other logic. As used in this document, "each" refers to each member of a set or each member of a subset of a set.

[0028] FIG. **6** shows one embodiment of a series of actions that may be performed to program and use remote explosive detonation system **10**. In act **100**, the process is initiated.

[0029] In act **102**, operating mode dial **22** is set to the programming mode. When the programming mode is selected, actuation of any receivers **14** may be inhibited. In this manner, premature detonation may be reduced.

[0030] In act **104**, Receiver **14** is docked to transmitter **12** by coupling receiver docking connector **32** to transmitter docking connector **20**. In one embodiment, receiver **14** includes an indicator light **38** that indicates its operating condition. For example, indicator light **38** may become illuminated when receiver **14** is docked on transmitter **12** to indicate that its circuit **52** is in an operational state and the battery is supplying ample electrical power for its operation.

[0031] In act **106**, identification code **72** stored in memory **64** of transmitter **12** is transferred to the memory **66** of receiver **14**. In one embodiment, commencement of identification code transferal is provided by actuation of trigger buttons **24**. In other embodiments, transferal of transmitter identification code **72** commences when receiver docking connector **32** is coupled to transmitter docking connector **20**. In one embodiment, indicator light may generate a blinking pattern indicating proper receipt and storage of identification code **70** in its internal memory **66**. In another embodiment, the blinking pattern may be indicative of the status of the receiver's battery **56**. For example, indicator light **38** may blink twice to indicate a fully charged battery while a three blink sequence may indicate a partially charged battery **56**.

[0032] In act **108**, receiver **14** is removed from transmitter **12** and coupled to a suitable explosive device. Receiver **14** may be coupled to various types of explosive devices using one of several accessory clips **44** that may be mounted on receiver **14**. In one embodiment, receiver **14** may incorporate a delay activation mechanism that inhibits detonation for a period of time following removal from transmitter **12**. In one embodiment, this delay time may be approximately 4 seconds.

[0033] In act **110**, if more than one receiver **14** is to be detonated simultaneously, acts **102** through **108** may be repeated with another receiver **14**. If only one receiver **14** is to be detonated, however, processing continues at act **112**.

[0034] in act **112**, operating mode dial **22** may be moved from the programming mode to a test mode. While operating mode dial **22** is in the test mode and the one or more receivers **14** are electrically decoupled from transmitter **12**, actuation of trigger buttons **24** causes indicator light **38** to generate a visual indication that its associated receiver **14** has properly received and its stored identification code **70** matches that of the transmitter identification code in the transmission signal. While in the test mode of operation, detonator **40** is inhibited from detonation. Thus, receivers **14** may be verified for proper operation with transmitter **12** following removal from transmitter docking connector **20**.

[0035] In act **114**, operating mode dial **22** may be moved to the disarm mode. While in the disarm mode of operation, actuation of trigger buttons **24** causes one or all of the one or more receivers **14** to be disarmed. In one embodiment, disarming of receivers **14** may be accomplished by erasing its stored internal identification code **70**. In this manner, receipt of an ensuing transmission signal including an identification code will not cause the receiver **14** to detonate the detonator **40**.

[0036] In act **115**, the one or more receivers **14** go to a storage mode. In the storage mode, the one or more receivers **14** may not detonate from detonation signals transmitted by transmitter **12**, but may be programmed by transmitter **12** in the future according to acts **102**, through **108**.

[0037] In act **116**, operating mode dial **22** is moved from the programming mode to the operation mode. In the operation mode, the trigger buttons **24** are no longer inhibited from generating a signal that may be used to detonate each of the receivers **14** programmed in acts **102** through **108**.

[0038] In act **118**, the one or more receiver **14** is detonated by transmitter **12** by actuating trigger buttons **24**. At this point, remote explosive detonation system **10** has remotely detonated an explosive and the process ends in act **120**.

[0039] Remote explosive detonation system **10** may have multiple safety mechanisms that reduce premature detonation. For example, the signal transmitted by transmitter **12** may include a spread spectrum transmission, forward error correction, layered coding, and/or error detection techniques to reduce interception or jamming by others. Additionally, detonator **40** may be void of any primary explosive material that is generally prone to premature detonation. Thus, remote explosive detonation system **10** may provide a relatively secure method for detonating one or more explosive devices from a distance using radio frequency transmission techniques in relatively reliable manner.

[0040] Although the present disclosure and its advantages have been described in detail, it should be understood that various changes, substitutions, and alterations can be made therein without departing from the spirit and scope of the disclosure as defined by the appended claims.

1. A remote explosive detonation system comprising:

a transmitter comprising a transmitter docking connector and operable to transmit an electro-magnetic signal using a spread spectrum transmission technique, the electro-magnetic signal comprising a transmitter identification code; and

a plurality of receivers that each comprises a receiver docking connector and a receiver housing that houses a detonator and a patch antenna operable to receive the electro-magnetic signal, each of the plurality of receivers operable to:

electrically couple to the transmitter by coupling its receiver docking connector to the transmitter docking connector;

receive the transmitter identification code from the transmitter;

store the transmitted identification code as an internal identification code;

receive the electro-magnetic signal from the patch antenna; and

simultaneously detonate its respective detonator if the transmitted identification code matches the internal identification code.

2. A remote explosive detonation system comprising:

a transmitter having a transmitter docking connector and operable to transmit an electro-magnetic signal comprising a transmitter identification code; and

at least one receiver comprising a receiver docking connector and a receiver housing that houses a detonator, the at least one receiver operable to:

electrically couple to the transmitter by coupling its receiver docking connector to the transmitter docking connector;

receive the transmitter identification code from the transmitter; and store the transmitter identification code as the internal identification code;

electrically decouple from the transmitter;

receive the electro-magnetic signal from the transmitter; and

detonate the detonator if the transmitter identification code matches an internal identification code stored in the receiver.

3. The remote explosive detonation system of claim **2**, further comprising a plurality of accessory clips that are each alternatively coupled to the at least one receiver, the plurality of accessory clips operable to couple the at least one receiver to differing types of explosives.

4. The remote explosive detonation system of claim **3**, wherein the plurality of accessory clips are selected from the group consisting of a claw accessory clip, a shock tube accessory clip, and a detonation cord accessory clip.

5. The remote explosive detonation system of claim **2**, wherein the at least one receiver is a plurality of receivers, the transmitter operable to transmit the electro-magnetic signal simultaneously to each of the plurality of receivers.

6. The remote explosive detonation system of claim **2**, wherein the at least one receiver comprises an arming/safety pin that is selectively removable from the at least one receiver, the at least one receiver being operable to allow detonation of the detonator in response to removal of the arming/safety pin.

7. The remote explosive detonation system of claim **2**, wherein the detonator comprises an exploding foil initiator.

8. The remote explosive detonation system of claim **2**, further comprising an indicator light configured on the at least one receiver, the indicator light operable to indicate an operational status of the at least one receiver.

9. The remote explosive detonation system of claim **8**, wherein the indicator light is operable to emit a blinking pattern indicative of a status of a battery that powers the receiver.

10. The remote explosive detonation system of claim **8**, wherein the indicator light is operable to emit only infrared light.

11. The remote explosive detonation system of claim **2**, wherein the electro-magnetic signal comprises a spread spectrum electro-magnetic signal.

12. The remote explosive detonation system of claim **2**, further comprising an antenna disposed within the receiver housing, the antenna operable to receive the electro-magnetic signal.

13. The remote explosive detonation system of claim **12**, further comprising a patch antenna disposed within the receiver housing, the patch antenna operable to receive the electro-magnetic signal.

14. The remote explosive detonation system of claim **2**, wherein the receiver is operable to, after storing the transmitter identification code, receive a disarm signal from the transmitter and erase the identification code stored in the receiver upon receipt of the disarm signal.

15. The remote explosive detonation system of claim **2**, wherein the receiver is operable to receive a test mode signal from the transmitter and emit, using an indicator light configured on the at least one receiver, a visual indication to indicate receipt of the test mode signal from the transmitter, the test mode signal not operable to detonate the detonator.

16. The remote explosive detonation system of claim **2**, wherein the transmitter is housed in a hand-held housing.

17. The remote explosive detonation system of claim **2**, wherein receiving the electro-magnetic signal from the transmitter comprises receiving the electro-magnetic signal comprising a data packet having a preamble and a post-amble, and comparing the transmitter identification code with the internal identification code if the preamble and the post-amble matches a specified sequence.

18. A method for detonating an explosive comprising:

electrically coupling a receiver to a transmitter;

copying a transmitter identification code from the transmitter to the receiver;

storing the transmitter identification code as an internal identification code in the receiver;

decoupling the receiver from the transmitter;

receiving an electro-magnetic signal from the transmitter, the electro-magnetic signal comprising the transmitter identification code; and

detonating a detonator housed in the receiver if the transmitter identification code matches a receiver identification code stored in a receiver, the detonator initiating the explosive.

19. The method of claim **18**, wherein initiating the explosive comprises initiating the explosive that is coupled to the receiver using one of a plurality of accessory clips, the one accessory clip coupling the receiver to one of a plurality of differing types of explosives.

20. The method of claim **18**, further comprising disabling detonation of the detonator while the receiver is electrically coupled to the transmitter.

21. The method of claim **18**, wherein detonating the detonator is the receiver comprises simultaneously detonating a plurality of detonator in a corresponding plurality of receivers.

22. The method of claim **18**, further comprising removing an arming/safety pin from the receiver to allow detonation of the detonator.

23. The method of claim **22**, further comprising disabling detonation of the detonator for a specified period of time after the arming/safety pin is removed from the transmitter.

24. The method of claim **18**, wherein detonating the detonator comprises detonating the detonator comprising an exploding foil initiator.

25. The method of claim **18**, further comprising, after storing the transmitter identification code, receiving a disarm signal from the transmitter and erasing the identification code stored in the receiver upon receipt of the disarm signal.

26. The method of claim **18**, further comprising receiving a test mode signal from the transmitter, and emitting, using an indicator light configured on the at least one receiver, a visual indication to indicate receipt of the test mode signal from the transmitter, the test mode signal detonating the detonator.

27. The method of claim **18**, wherein receiving the electro-magnetic signal from the transmitter comprises receiving the electro-magnetic signal comprising a data packet having a preamble and a post-amble, and comparing the transmitter identification code with the internal identification code if the preamble and the post-amble matches a specified sequence.

* * * * *