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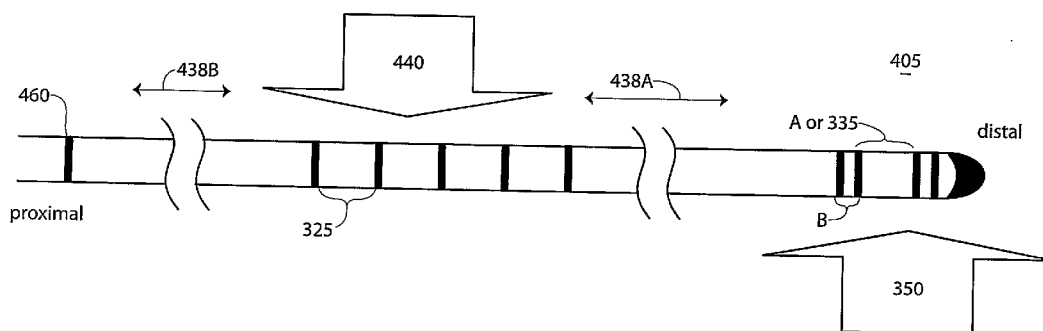
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(54) Title: COMPLEMENTARILY CONFIGURED CATHETER KIT FOR INTRACARDIAC RECORDING AND/OR PACING



(57) Abstract: A catheter kit can include a pair of catheters, having different and complimentary electrode configurations each configured to provide access to different intraluminal electrophysiological monitoring and/or pacing sites during a procedure.



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## COMPLEMENTARILY CONFIGURED CATHETER KIT FOR INTRACARDIAC RECORDING AND/OR PACING

### RELATED APPLICATIONS

- 5           This application claims priority to U.S. Provisional Application 60/705,867, filed August 5, 2005, the disclosure of which is incorporated by reference in its entirety.

### FIELD OF THE INVENTION

- 10           The invention relates to catheters for intracardiac electrocardiac recording and or pacing of a heart.

### BACKGROUND

- 15           Some diagnostic electrophysiological studies call for the simultaneous use of a number of multi electrode catheters to obtain intracardiac recordings, perform cardiac pacing, and guide therapy (*e.g.* catheter ablation). For example, catheter ablation for complex cardiac arrhythmias often requires placement of multiple intracardiac electrode catheters for recording intracardiac electrograms from various sites and/or pacing from any of multiple sites in each of the heart chambers. These catheters are sometimes referred to as diagnostic catheters. In some catheter ablation procedures, 20 four different diagnostic catheters are used to record intracardiac electrograms from different locations, such as the right atrium, the right ventricle, left atrium, and inter-atrial septum/HIS bundle region. Additional diagnostic or non-diagnostic catheters may also be used, including an ablation catheter.

- 25           Accordingly, such procedures conducted using a relatively large number of catheters may be rather cumbersome. Furthermore, access to organs, such as the heart, may be limited by the number of blood vessels or pathways suitable for catheter insertion. The need to use multiple catheters for recording and pacing may limit availability of vascular access sites for other types of catheters such as intracardiac 30 imaging catheters (*e.g.* intracardiac ultrasound), new mapping catheters (*e.g.* circular mapping catheters) or new therapeutic catheters (*e.g.* ablation catheters using cryotherapy or ablative ultrasound energy) that may be required during the same procedure.

## SUMMARY

According to some embodiments of the invention, a catheter kit includes a pair of catheters, having different and complimentary electrode configurations each configured to provide access to different intraluminal electrophysiological monitoring and/or pacing sites during a procedure.

According to some embodiments, a catheter kit includes a first catheter including a first electrode configuration to provide access to a plurality of first intraluminal electrophysiological monitoring and/or pacing sites via a first pathway during a procedure. A second catheter includes a second electrode configuration to provide access to a plurality of second intraluminal electrophysiological monitoring and/or pacing sites during the procedure.

According to some embodiments, a catheter kit includes a first catheter comprising a first plurality of electrodes on a distal portion of the first catheter having a spacing of 2-5-2 therebetween and comprising a second plurality of electrodes on a proximal portion of the first catheter having a spacing of about 8 mm therebetween. The first and second pluralities of electrodes have a gap therebetween of about 33 mm. A second catheter includes a third plurality of electrodes on a distal portion of the second catheter having a spacing of 2-5-2 therebetween and a fourth plurality of electrodes on a proximal portion of the second catheter having a spacing of about 5 mm therebetween. The pluralities of first and second electrodes have a gap therebetween of about 25 mm.

In some embodiments, a catheter includes a catheter body configured for insertion into the heart during a procedure. The catheter body has a first plurality of electrodes at a proximal portion thereof and a second plurality of electrodes at a distal portion thereof. The first plurality of electrodes is configured to monitor electrophysiological signals and/or pace at an inter-atrial septum/HIS bundle region of a heart and the second plurality of electrodes is configured to monitor electrophysiological signals and/or pace at a right ventricle of the heart. In particular embodiments, at least one additional electrode is spaced apart from the first plurality of electrodes by a second gap opposite the second plurality of electrodes.

## BRIEF DESCRIPTION OF THE DRAWINGS

**Figure 1a** is a schematic diagram illustrating a kit of two catheters inserted into the heart of a patient during a procedure according to some embodiments of the current invention;

**Figures 1b-1c** are fluoroscopic images of the kit of catheters of **Figure 1a** shown in use; and

**Figures 2-4** are schematic diagrams of catheters according to some embodiments of the current invention.

#### DESCRIPTION OF EMBODIMENTS ACCORDING TO THE INVENTION

Embodiments of the present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

In some embodiments according the invention, catheters and/or a catheter kit can allow the acquisition of intracardiac electrode recordings and/or delivery of pacing stimuli which may otherwise require the use of additional catheters.

In particular embodiments, catheters in a two catheter kit can have a specific configuration of electrodes thereon. Moreover, the configuration of each of the catheters may be complementary to one another. Two "complementary" catheters may each provide a function that is different from the function(s) provided by the other complementary catheter. A "kit" can be sold together and/or may include instructions concerning how to use the catheters together, for example, as a complementary pair.

In certain embodiments, a catheter includes a catheter body configured for insertion into the heart during a procedure. The catheter body has a first plurality of electrodes at a proximal portion thereof and a second plurality of electrodes at a distal portion thereof. The first and second plurality of electrodes are configured to monitor electrophysiological signals and/or pace at specific cardiac regions.

As illustrated in **Figure 1A**, a heart **10** includes the right ventricle "RV" **32**, the left ventricle "LV" **34**, the right atrium "RA" **36**, the left atrium "LA" **38**, the superior vena cava **48**, the atrioventricle junction "AV" or inter-atrial septum/HIS bundle

region **52**, the coronary sinus "CS" **42**, the great cardiac vein **44**, the left pulmonary artery **45**, and the coronary sinus ostium or "os" **40**. A first catheter **100** in the kit can be configured for use in a first part of the heart (accessed via a first pathway **110**), whereas a second catheter **105** may be configured for use in a second part of the heart  
5 (accessed via a second pathway **115**). The catheters **100**, **105** can be controlled and/or electrophysiological information can be displayed on a controller/monitor (such as controller/monitor **20** connected to catheter **100**). Accordingly, each of the catheters **100**, **105** may be configured with a different number and/or placement of electrodes depending on which areas are to be treated and depending on how the catheter is to be  
10 inserted into the body. Furthermore, in some embodiments according to the invention, the spacing between the electrodes on the catheters may be selected with the specific use and/or pathway in mind so that the spacing allows access to the desired sites within the heart in a convenient way and to provide complementarity between the catheters in the kit.

15 Although the catheters **100**, **105** are illustrated as being a two catheter kit, it should be understood that the catheters **100**, **105** may also be employed separately. The catheters **100**, **105** are configured for insertion into the body during a procedure, such as a cardiac ablation procedure for treatment of cardiac arrhythmias. After the procedure is completed, the catheters **100**, **105** may be removed from the body. As  
20 shown in **Figure 1**, the catheter **100** is inserted into the right internal jugular vein and the catheter **105** is inserted into the right femoral vein; however, it should be understood that other suitable access points may be used.

With continued reference to **Figure 1**, the catheter **100** includes a group of electrodes **120** at a proximal portion of the catheter **100** and another group of  
25 electrodes **130** at a distal portion of the catheter **100**. The two groups of electrodes **120**, **130** are spaced apart from one another by a gap **138A**. As illustrated, the catheter **100** is positioned in the coronary sinus **42** and the right atrium **36**. In this configuration, the group of electrodes **120** can record electrical activity and/or pace within the coronary sinus **42** (which can include pacing and/or recording electrical  
30 activity for the left atrium **38** and/or left ventricle **34** of the heart **10**) and the group of electrodes **130** can record electrical activity and/or pace the high lateral or lateral portion of the right atrium **36** of the heart **10**.

The catheter **105** includes a group of electrodes **140** at a proximal portion of the catheter **105** and another group of electrodes **150** at a distal portion of the catheter

105. The two groups of electrodes **140, 150** are spaced apart from one another by a gap **138B**. As shown, the catheter **105** is positioned in the right atrium **36** and is depicted over the catheter **100** and in the right ventricle **32**. In this configuration, the group of electrodes **140** can record electrical activity and/or pace at the atrioventricle  
5 junction or inter-atrial septum/HIS bundle region **52** of the heart **10** and the group of electrodes **150** can record electrical activity and/or pace the right ventricle **32** of the heart **10**. The catheter **105** can include at least one optional electrode **160**, which may be used for complex ventricular ablation for unipolar pacing and/or recording electrical activity.

10 Although the catheters **100** and **105** are illustrated with respect to groups of electrodes **120, 130, 140** and **150** that are configured to record electrical activity and/or pace at the right atrium **36**, left atrium **38**, inter-atrial septum/HIS bundle region **52** and the right ventricle **32**, respectively, it should be understood that other electrode configurations can be used to record electrical activity and/or pace in  
15 various other regions of the heart.

Images of the catheters **100** and **105** are shown in **Figures 1B-1C**.

Embodiments according to the present invention are illustrated with respect to catheters **200, 305** and **405** shown in **Figures 2, 3** and **4**, respectively. It should be understood that the catheters **200, 305** and **405** can be used individually or in  
20 combination with one or more other catheters. In particular embodiments according to the invention, the catheters **200** and **305** can be used as a complementary pair such that the catheter **200** may be positioned to record electrical activity and/or pace at the right atrium **36** and left atrium **38**, and the catheter **305** may be positioned to record electrical activity and/or pace in the inter-atrial septum/HIS bundle region **52** and the  
25 right ventricle **32**. In certain embodiments according to the invention, the catheters **200** and **405** can be used as a complementary pair. That is, the catheter **200** may be positioned to record electrical activity and/or pace at the right atrium **36** and the left atrium **38**, and the catheter **405** may be positioned to record electrical activity and/or pace in the inter-atrial septum/HIS bundle region **52** and the right ventricle **32**. In  
30 addition to providing an additional electrode or pair of electrodes for unipolar pacing or recording.

As shown in **Figure 2**, in some embodiments according to the invention, a catheter **200** can include a group of electrodes **220** at a proximal portion of the first catheter **200**, and another group of electrodes **230** at a distal portion of the first

catheter **200**. The group of electrodes **220** can be spaced apart from the group of electrodes by a gap **238**. The group of electrodes **220** can be spaced apart from one another by a first spacing **225** and the group of electrodes **230** can be spaced apart from one another by a second spacing **A** and/or **B**. For example, in some  
5   embodiments according to the invention, electrodes of one group of electrodes can be spaced apart to allow left atrial recordings accessed via the coronary sinus (*i.e.*, a pathway), whereas the other group can be spaced apart to obtain recordings from the high lateral or lateral right atrium.

10       In some embodiments according to the invention, the gap **238** can be about 33mm. It will be understood that the gap **238** may be free of other electrodes or alternatively, any electrodes located within the gap may be unused. In some embodiments according to the invention, the first group of electrodes **220** includes six electrodes arranged with between 5 and 10 mm spacing from one another, or in particular, an 8mm spacing from one another. In other embodiments, the first group  
15   of electrodes **220** includes ten electrodes. In some embodiments according to the invention, the second group of electrodes **230** includes ten electrodes arranged in a 2–5–2 mm spacing. In particular, the electrodes with the second group **230** can be arranged in pairs having a spacing of about 2 mm between them (see **B** in **Figure 2**). The pairs are spaced apart by about 5 mm (see **A** in **Figure 2**). In some embodiments,  
20   the electrodes described herein are 2 mm wide metal electrodes formed from a combination of platinum and/or iridium.

As shown in **Figure 3**, in some embodiments according to the invention, a catheter **305** can include a group of electrodes **340** at a proximal portion of the catheter **305**, and another group of electrodes **350** at a distal portion of the catheter  
25   **305**. The group of electrodes **340** can be spaced apart from the group of electrodes **350** by a gap **338**, which can be about 25 mm, or larger for patients with large hearts (*e.g.*, 35 mm). The group of electrodes **340** can be spaced apart from one another by a spacing **325** and the group of electrodes **350** can be spaced apart from one another by a spacing **335** or alternate spacings **A** and **B**. It will be understood that the gap **338**  
30   may be free of other electrodes or alternatively, any electrodes located within the gap may be unused.

Referring to **Figure 4**, in some embodiments according to the invention, a catheter **405** can include a group of electrodes **440** at a proximal portion of the catheter **405**, and another group of electrodes **450** at a distal portion of the catheter

405. A single electrode **460** (or a pair of electrodes, for example, spaced apart from one another by 5 mm) can be positioned at a most proximal portion of the catheter **405**. In some embodiments, two, three or more electrodes can be used for the electrode **460**. The group of electrodes **440** can be spaced apart from the group of electrodes **450** by a gap **438A**, and the group of electrodes **440** can be spaced apart from the electrode **460** by another gap **438A**. The group of electrodes **440** can be spaced apart from one another by a spacing **425** and the group of electrodes **450** can be spaced apart from one another by a spacing **435** or alternate spacings **A** and **B**. It will be understood that the gaps **438A**, **438B** may be free of other electrodes or alternatively, any electrodes located within the gap may be unused.

It will be understood that the gap between the groups of electrodes can be selected based on a particular anatomical characteristic of a group of patients. For example, the gap **238** for a catheter used to treat patients with relatively large hearts may be more than 33 mm. In contrast, the gap for a catheter used to treat patients with relatively small hearts (such as children) may be less than 33 mm. In addition, the gaps **238** and **338** may be different from one another in order to obtain the desired placement of the groups of electrodes **220**, **230**, **340**, and **350**. For example, the gap **238** can be about 25-50 mm, or in particular, about 33 mm, and the gaps **338**, **438A** can be about 15-35 mm, or in particular, about 25 mm. The gap **438B** can be about 10-40 cm, or in particular, about 25 cm or 30 cm such that the electrode **460** is positioned in the iliac vein or inferior vena cava vein, for example, for unipolar pacing and/or recording, such as is shown in **Figure 1A** with respect to the electrode **160**.

In some embodiments according to the invention shown in **Figure 3**, the group of electrodes **340** includes 6 electrodes arranged with a 5 mm spacing from one another. In some embodiments according to the invention, the group of electrodes **350** includes 4 electrodes arranged with a 2-5-2 spacing from one another. In some embodiments according to the invention as shown in **Figure 4**, the group of electrodes **440** includes 5 electrodes arranged with a 5 mm from one another, and the group of electrodes **450** includes 4 electrodes arranged with a 2-5-2 spacing from one another. In still further embodiments according to the invention, the electrodes may have different or irregular spacings than those described above in reference to **Figures 2, 3** and **4**. In some embodiments according to the invention, the electrode spacing may be selected based on a desired operation of the catheter.



As described above, the catheter **200** shown in **Figure 2** can be configured for use in a first part of the heart (accessed via, for example, the first pathway **110** of **Figure 1A**), whereas the catheters **305**, **405** shown in **Figures 3** and **4** may be configured for use in a second part of the heart (accessed via, for example, the second pathway **115** of **Figure 1A**). For example, the catheter **200** can be used to record and/or pace the right atrial/coronary sinus (RA/CS) and can be inserted via the right internal jugular vein. The catheters **305**, **405** can be used to record and/or pace from a plurality of regions, for example, the right ventricle and inter-atrial septum/HIS bundle region via a catheter inserted into the heart via the right femoral vein. In still further embodiments according to the invention, the two catheters are configured to provide complimentary recordings, but access, for example, the heart via the same blood vessel (*i.e.*, pathway).

Although embodiments according to the invention are illustrated with respect to two catheters, such as the catheter pair **100**, **105**, the catheter pair **200**, **305**, or the catheter pair **200**, **405** it should be understood that a single catheter may be used or three or more complementary catheters may be used.

It will be understood that when an element is referred to as being "on", "connected to" or "coupled to" another element, it can be directly on, connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly on," "directly connected to" or "directly coupled to" another element, there are no intervening elements present. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. In the figures, the thickness and/or sizes of certain lines, layers, components, elements or features may be exaggerated for clarity and/or may not be drawn to scale.

It will be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

Spatially relative terms, such as "beneath", "below", "lower", "above", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different  
5 orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise  
10 oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well,  
15 unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

Embodiments of the invention may be described herein with reference to  
20 illustrations that are schematic illustrations of idealized embodiments of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions  
25 illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms,  
30 such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

In the drawings and specification, there have been disclosed typical embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

5

**Claims:**

1. A catheter kit comprising:  
a pair of catheters, having different and complimentary electrode configurations each configured to provide access to different intraluminal electrophysiological monitoring and/or pacing sites during a procedure.
2. The catheter kit according to Claim 1, wherein a first catheter of the pair of catheters includes a first plurality of electrodes at a proximal portion thereof and a second plurality of electrodes at a distal portion thereof, wherein the first plurality of electrodes is configured to monitor electrophysiological signals and/or pace at a right atrium of a heart and the second plurality of electrodes is configured to monitor electrophysiological signals and/or pace within the coronary sinus.
3. The catheter kit according to Claim 2, wherein the first and second plurality of electrodes are spaced apart by a first gap.
4. The catheter kit according to Claim 3, wherein the first gap is between about 25 and 50 mm.
5. The catheter kit according to Claim 2, wherein the first plurality of electrodes are spaced apart from one another by a first spacing pattern and the second plurality of electrodes are spaced apart from one another by a second spacing pattern, and the first spacing pattern is different from the second spacing pattern.
6. The catheter kit according to Claim 5, wherein the first spacing pattern includes at least six electrodes arranged between about 5 and 10 mm from one another.
7. The catheter kit according to Claim 5, wherein the second spacing pattern includes at least ten electrodes comprising five pairs of electrodes having a spacing of about 2 mm between each of the electrodes in a pair, and each pair of electrodes are spaced apart by about 5 mm from an adjacent pair.

8. The catheter kit according to Claim 2, wherein the first catheter is configured for insertion via the right internal jugular vein.

9. The catheter kit according to Claim 2, wherein a second catheter of the pair of catheters includes a third plurality of electrodes at a proximal portion thereof and a fourth plurality of electrodes at a distal portion thereof, wherein the third plurality of electrodes is configured to monitor electrophysiological signals and/or pace at an inter-atrial septum/HIS bundle region of a heart and the fourth plurality of electrodes is configured to monitor electrophysiological signals and/or pace at a right ventricle of the heart.

10. The catheter kit according to Claim 9, wherein the third and fourth plurality of electrodes are spaced apart by a second gap.

11. The catheter kit according to Claim 10, wherein the second gap is between about 15 and 35 mm.

12. The catheter kit according to Claim 9, wherein the third plurality of electrodes are spaced apart from one another by a third spacing pattern and the fourth plurality of electrodes are spaced apart from one another by a fourth spacing pattern, and the third spacing pattern is different from the fourth spacing pattern.

13. The catheter kit according to Claim 12, wherein the third spacing pattern includes at least six electrodes arranged about 5 mm from one another.

14. The catheter kit according to Claim 12, wherein the third spacing pattern includes at least five electrodes arranged about 5 mm from one another.

15. The catheter kit according to Claim 14, further comprising at least one additional electrode spaced apart from the third plurality of electrodes by a third gap opposite the fourth plurality of electrodes.

16. The catheter kit according to Claim 15, wherein the third gap is between about 10 and 40 cm.

17. The catheter kit according to Claim 12, wherein the first spacing pattern includes at least four electrodes comprising two pairs of electrodes having a spacing of about 2 mm between each of the electrodes in a pair, and each pair of  
5 electrodes are spaced apart by about 5 mm from an adjacent pair.

18. The catheter kit according to Claim 9, wherein the second catheter is configured for insertion via the right femoral vein.

10 19. A catheter kit comprising:  
a first catheter including a first electrode configuration to provide access to a plurality of first intraluminal electrophysiological monitoring and/or pacing sites via a first pathway during a procedure; and  
a second catheter including a second electrode configuration to provide access  
15 to a plurality of second intraluminal electrophysiological monitoring and/or pacing sites during the procedure.

20. The catheter kit according to Claim 19 wherein the second catheter is configured to provide access to the plurality of second intraluminal  
20 electrophysiological monitoring and/or pacing sites via the first pathway.

21. A catheter kit according to Claim 19 wherein the second catheter is configured to provide access to the plurality of second intraluminal electrophysiological monitoring and/or pacing sites via a second pathway, that is  
25 different than the first pathway.

22. A catheter kit comprising:  
a first catheter comprising a first plurality of electrodes on a distal portion of the first catheter having a spacing of 2-5-2 therebetween and comprising a second  
30 plurality of electrodes on a proximal portion of the first catheter having a spacing of about 8 mm therebetween, the first and second pluralities of electrodes having a gap therebetween of about 33 mm; and

a second catheter comprising a third plurality of electrodes on a distal portion of the second catheter having a spacing of 2-5-2 therebetween and comprising a

fourth plurality of electrodes on a proximal portion of the second catheter having a spacing of about 5 mm therebetween, the pluralities of first and second electrodes having a gap therebetween of about 25 mm.

5           23.     A catheter comprising:

          a catheter body configured for insertion into the heart during a procedure, the catheter body having a first plurality of electrodes at a proximal portion thereof and a second plurality of electrodes at a distal portion thereof, wherein the first plurality of electrodes is configured to monitor electrophysiological signals and/or pace at an  
10   inter-atrial septum/HIS bundle region of a heart and the second plurality of electrodes is configured to monitor electrophysiological signals and/or pace at a right ventricle of the heart.

          24.     The catheter according to Claim 23, wherein the first and second  
15   plurality of electrodes are spaced apart by a gap.

          25.     The catheter according to Claim 24, wherein the gap is between about 15 and 35 mm.

20           26.     The catheter according to Claim 23, wherein the first plurality of electrodes are spaced apart from one another by a first spacing pattern and the second plurality of electrodes are spaced apart from one another by a second spacing pattern, and the first spacing pattern is different from the second spacing pattern.

25           27.     The catheter according to Claim 26, wherein the first spacing pattern includes at least six electrodes arranged about 5 mm from one another, and the second spacing pattern includes at least four electrodes comprising two pairs of electrodes having a spacing of about 2 mm between each of the electrodes in a pair, and each pair of electrodes are spaced apart by about 5 mm from an adjacent pair.  
30

          28.     The catheter according to Claim 26, wherein the first spacing pattern includes at least five electrodes arranged about 5 mm from one another, and the second spacing pattern includes at least four electrodes comprising two pairs of

electrodes having a spacing of about 2 mm between each of the electrodes in a pair, and each pair of electrodes are spaced apart by about 5 mm from an adjacent pair.

29. The catheter according to Claim 28, further comprising at least one  
5 additional electrode spaced apart from the first plurality of electrodes by a second gap opposite the second plurality of electrodes.

30. The catheter according to Claim 28, wherein the second gap is between  
about 10 and 40 cm.

10



Fig. 1

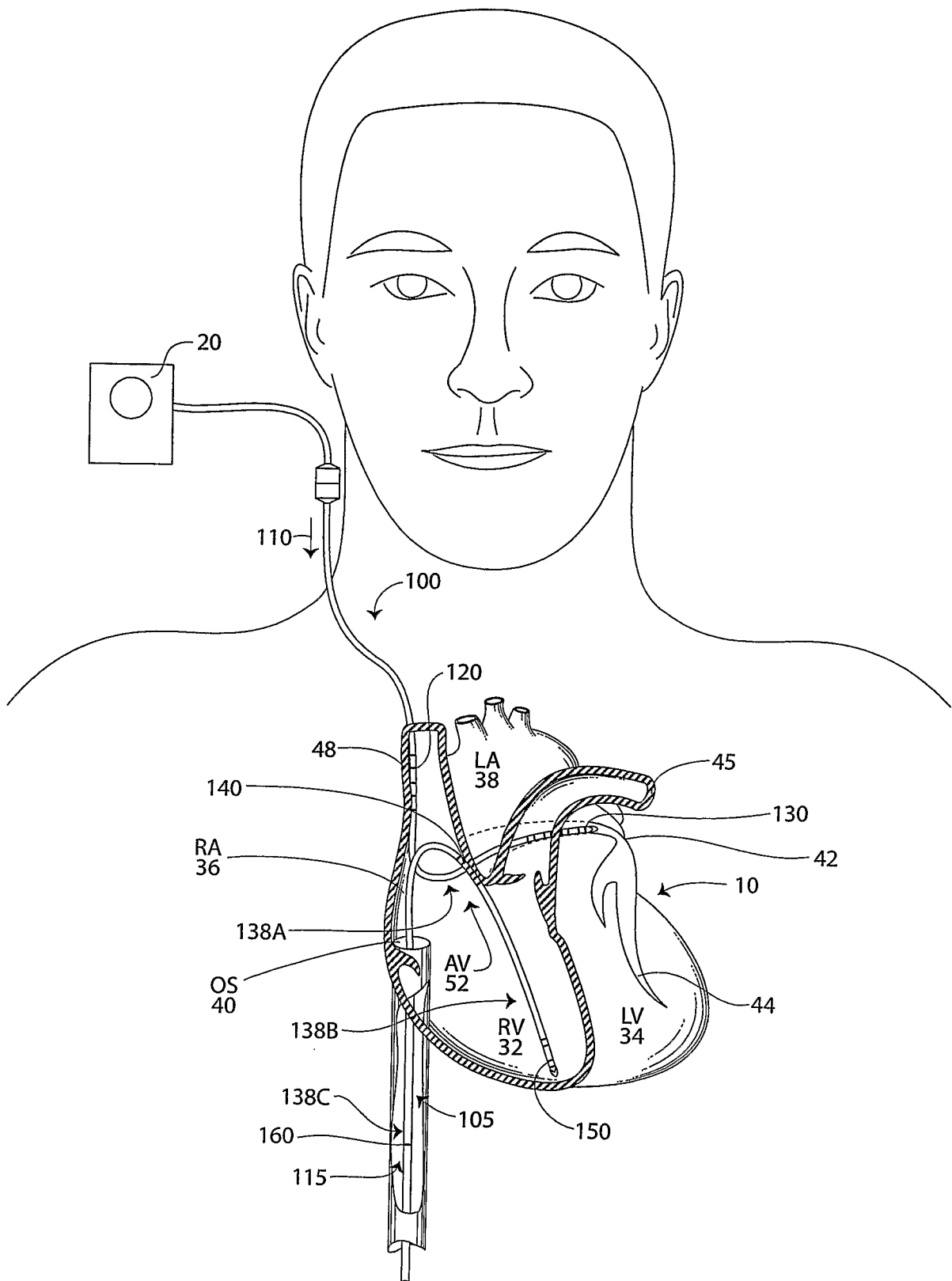


Fig. 1B

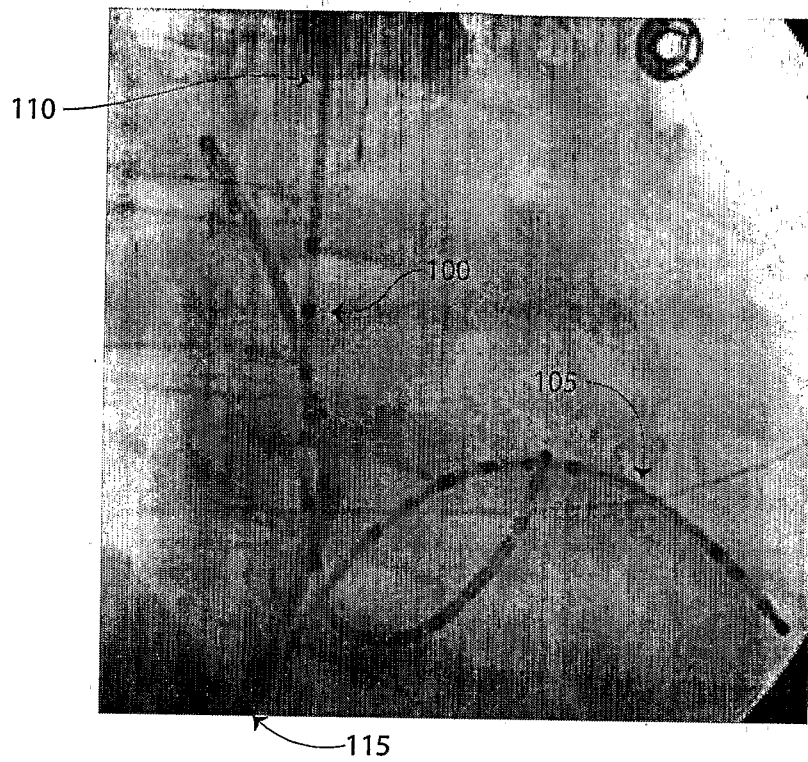


Fig. 1C

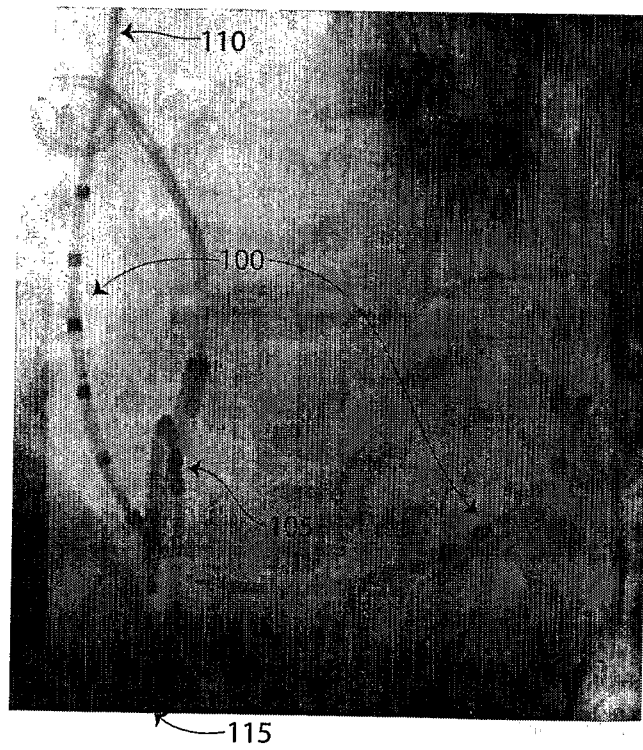


Fig. 2

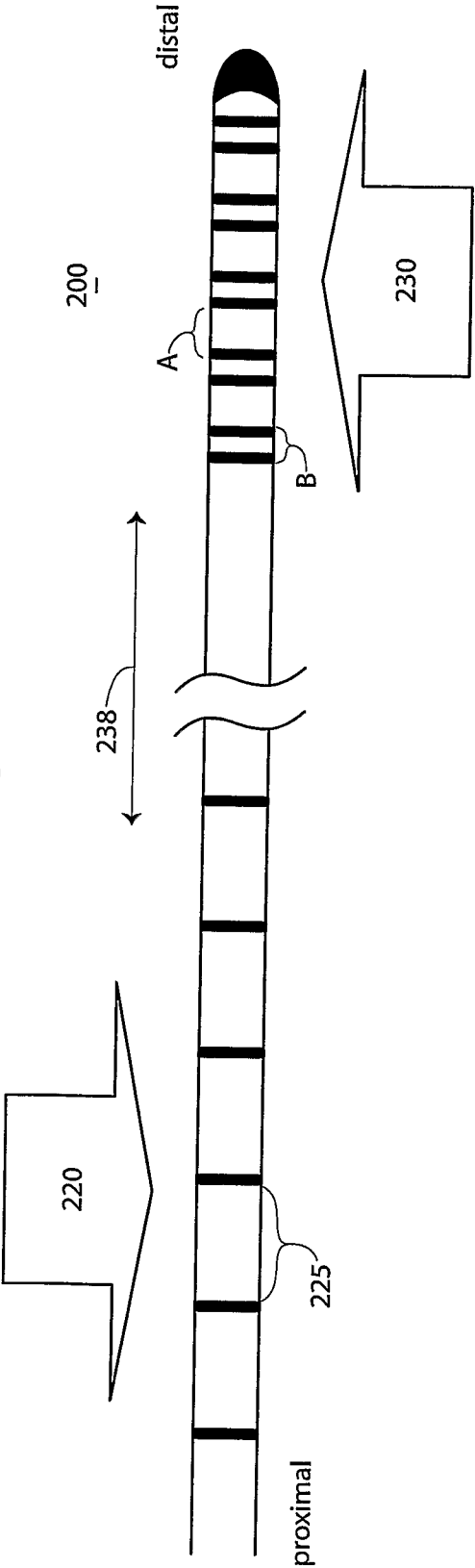


Fig. 3

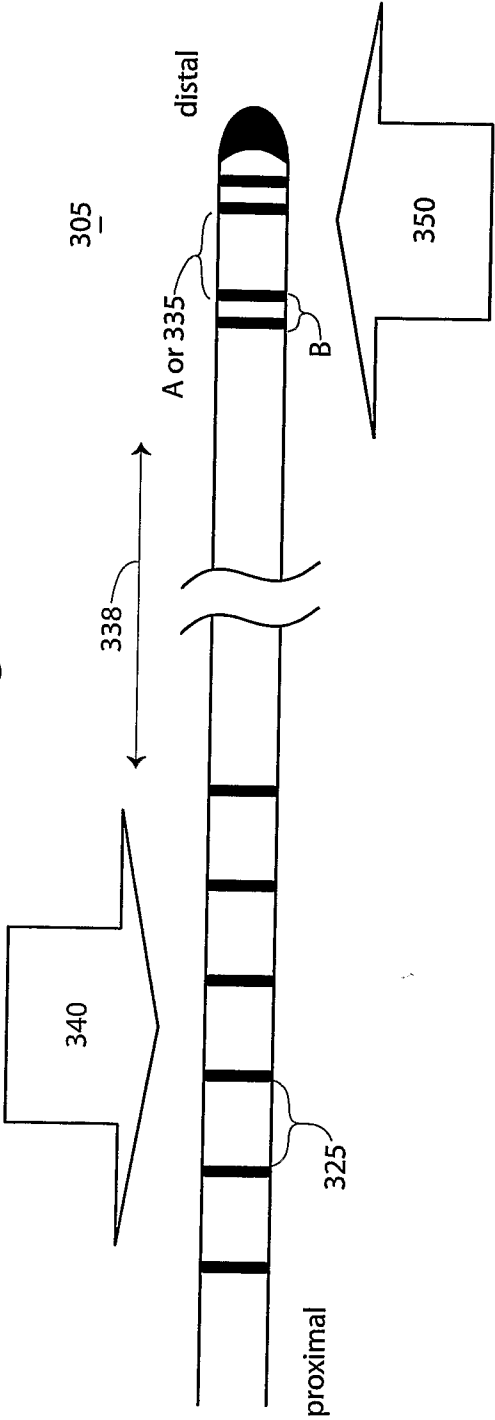


Fig. 4

