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CA 2841792 A1 2013/01/10

(21) 2 841 792

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2012/07/05
(87) Date publication PCT/PCT Publication Date: 2013/01/10
(85) Entrée phase nationale/National Entry: 2014/01/03
(86) N° demande PCT/PCT Application No.: US 2012/045478
(87) N° publication PCT/PCT Publication No.: 2013/006660
(30) Priorité/Priority: 2011/07/06 (US13/176,778)

(51) Cl.Int./Int.Cl. *E21B 43/24* (2006.01), *E21B 36/04* (2006.01), *E21B 43/30* (2006.01)

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(54) Titre : PROCEDE PERMETTANT UNE RECUPERATION D'HYDROCARBURE A L'AIDE D'UN DRAINAGE PAR GRAVITE AU MOYEN DE VAPEUR (SAGD) ET DE PUITS DE REMPLISSAGE DOTES D'UN CHAUFFAGE PAR RADIOFREQUENCE(RF)

(54) Title: METHOD FOR HYDROCARBON RECOVERY USING SAGD AND INFILL WELLS WITH RF HEATING

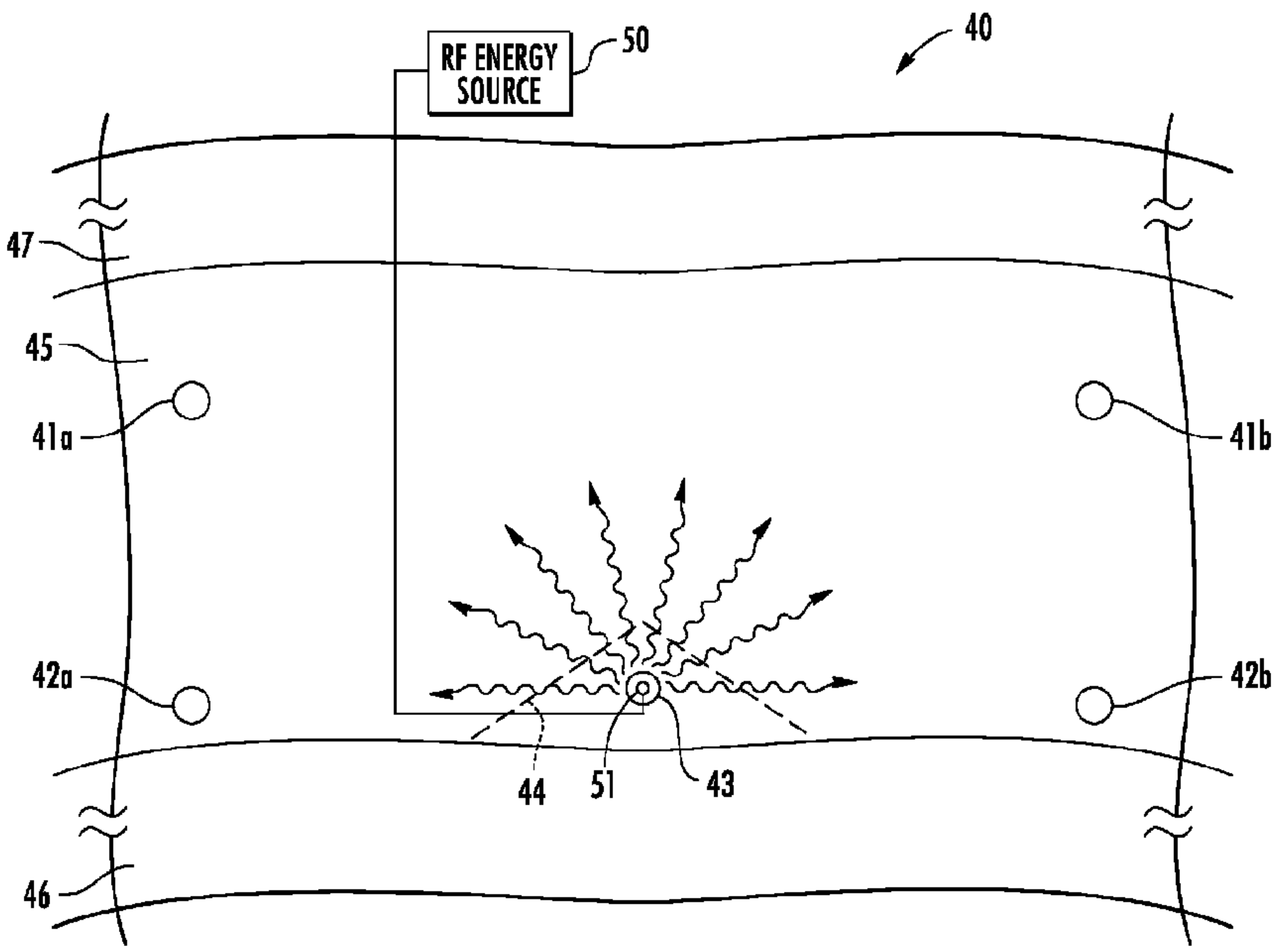

FIG. 2

(57) Abrégé/Abstract:
A method for hydrocarbon resource recovery in a subterranean formation (41) may include forming spaced apart injector/producer well pairs in the subterranean formation, with each well pair including a laterally extending producer well (42a, 42b) and a laterally extending injector well (41a, 41b) spaced thereabove. The method may also include forming laterally extending infill wells (43) in the subterranean formation, with each infill well being located between respective adjacent injector/producer well pairs. The method may also include recovering hydrocarbon resources from the producer wells based upon Steam Assisted Gravity Drainage (SAGD) via the injector/ producer well pairs, and recovering hydrocarbon resources from the infill wells based upon RF heating regions of the subterranean formation surrounding the respective infill wells.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 January 2013 (10.01.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/006660 A3

(51) International Patent Classification:
E21B 43/24 (2006.01) *E21B 36/04* (2006.01)
E21B 43/30 (2006.01)

(21) International Application Number:
PCT/US2012/045478

(22) International Filing Date:
5 July 2012 (05.07.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/176,778 6 July 2011 (06.07.2011) US

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
28 November 2013

(54) Title: METHOD FOR HYDROCARBON RECOVERY USING SAGD AND INFILL WELLS WITH RF HEATING

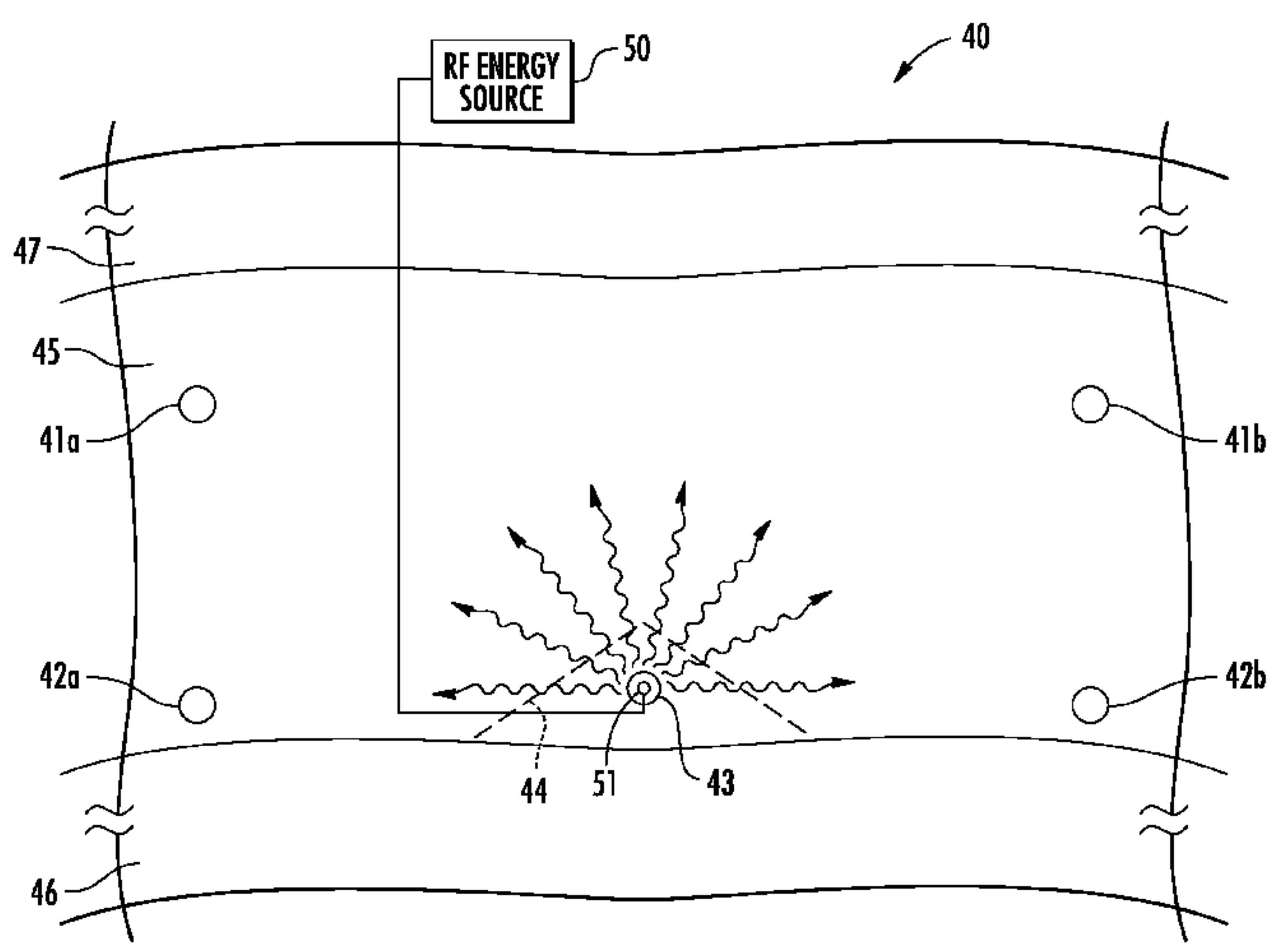

FIG. 2

(57) Abstract: A method for hydrocarbon resource recovery in a subterranean formation (41) may include forming spaced apart injector/producer well pairs in the subterranean formation, with each well pair including a laterally extending producer well (42a, 42b) and a laterally extending injector well (41a, 41b) spaced thereabove. The method may also include forming laterally extending infill wells (43) in the subterranean formation, with each infill well being located between respective adjacent injector/producer well pairs. The method may also include recovering hydrocarbon resources from the producer wells based upon Steam Assisted Gravity Drainage (SAGD) via the injector/ producer well pairs, and recovering hydrocarbon resources from the infill wells based upon RF heating regions of the subterranean formation surrounding the respective infill wells.

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METHOD FOR HYDROCARBON RECOVERY USING SAGD AND INFILL WELLS WITH RF HEATING

The present invention relates to the field of hydrocarbon resource recovery, and, more particularly, to hydrocarbon resource recovery using RF heating.

Energy consumption worldwide is generally increasing, and conventional hydrocarbon resources are being consumed. In an attempt to meet demand, the exploitation of unconventional resources may be desired. For example, highly viscous hydrocarbon resources, such as heavy oils, may be trapped in tar sands where their viscous nature does not permit conventional oil well production. Estimates are that trillions of barrels of oil reserves may be found in such tar sand formations.

In some instances these tar sand deposits are currently extracted via open-pit mining. Another approach for *in situ* extraction for deeper deposits is known as Steam-Assisted Gravity Drainage (SAGD). The heavy oil is immobile at reservoir temperatures and therefore the oil is typically heated to reduce its viscosity and mobilize the oil flow. In SAGD, pairs of injector and producer wells are formed to be laterally extending in the ground. Each pair of injector/producer wells includes a lower producer well and an upper injector well. The injector/producer wells are typically located in the payzone of the subterranean formation between an underburden layer and an overburden layer.

The upper injector well is used to typically inject steam, and the lower producer well collects the heated crude oil or bitumen that flows out of the formation, along with any water from the condensation of injected steam. The injected steam forms a steam chamber that expands vertically and horizontally in the formation. The heat from the steam reduces the viscosity of the heavy crude oil or bitumen which allows it to flow down into the lower producer well where it is collected and recovered. The steam and gases rise due to their lower density so that steam is not produced at the lower producer well and steam trap control is used to the same affect. Gases, such as methane, carbon dioxide, and hydrogen sulfide, for example, may tend to rise in the steam chamber and fill the void space left by the oil defining an insulating layer above the steam. Oil and water flow is by gravity driven drainage, into the lower producer well.

Operating the injection and production wells at approximately reservoir pressure may address the instability problems that adversely affect high-pressure steam processes. SAGD may produce a smooth, even production that can be as high as 70% to 80% of the original oil in place (OOIP) in suitable reservoirs. The SAGD process may be relatively sensitive to shale streaks and other vertical barriers since, as the rock is heated, differential thermal expansion causes fractures in it, allowing steam and fluids to flow through. SAGD may be twice as efficient as the older cyclic steam stimulation (CSS) process.

Many countries in the world have large deposits of oil sands, including the United States, Russia, and various countries in the Middle East. Oil sands may represent as much as two-thirds of the world's total petroleum resource, with at least 1.7 trillion barrels in the Canadian Athabasca Oil Sands, for example. At the present time, only Canada has a large-scale commercial oil sands industry, though a small amount of oil from oil sands is also produced in Venezuela. Because of increasing oil sands production, Canada has become the largest single supplier of oil and products to the United States. Oil sands now are the source of almost half of Canada's oil production, although due to the 2008 economic downturn work on new projects has been deferred, while Venezuelan production has been declining in recent years. Oil is not yet produced from oil sands on a significant level in other countries.

Unfortunately, long production times to extract oil using SAGD may lead to significant heat loss to the adjacent soil, excessive consumption of steam, and a high cost for recovery. Significant water resources are also typically used to recover oil using SAGD which impacts the environment. Limited water resources may also limit oil recovery.

U.S. Published Patent Application No. 2010/0078163 to Banerjee et al. discloses a hydrocarbon recovery process whereby three wells are provided: an uppermost well used to inject water, a middle well used to introduce microwaves into the reservoir, and a lowermost well for production. A microwave generator generates microwaves which are directed into a zone above the middle well through a series of waveguides. The frequency of the microwaves is at a frequency substantially equivalent to the resonant frequency of the water so that the water is heated.

Along these lines, U.S. Published Application No. 2010/0294489 to Dreher, Jr. et al. discloses using microwaves to provide heating. An activator is injected below the surface and is heated by the microwaves, and the activator then heats the heavy oil in the production well. U.S. Published Application No. 2010/0294488 to Wheeler et al. discloses a similar approach.

U.S. Patent No. 5,046,559 to Glandt discloses a method for producing oil from tar sands by electrically preheating paths of increased injectivity between an injector well and a pair of producer wells arranged in a triangular pattern. The paths of increased injectivity are then steam flooded to produce the hydrocarbon resources.

Unfortunately, SAGD may not efficiently permit recovery of the hydrocarbon resources in a wedge region between adjacent pairs of injector/producer wells as disclosed, for example, in U.S. Patent No. 7,556,099 to Arthur et al. While the steam chambers of adjacent pairs of injector/producer wells will typically grow into hydraulic communication with one another, there is still typically the lower area between adjacent injector/producer well pairs (the wedge region) from which the hydrocarbon resources are not recovered. The Arthur et al. patent discloses adding an infill well in the wedge region between adjacent pairs of injector/producer wells. A mobilizing fluid in the form of steam is injected into the infill well until fluid communication is established between the adjacent steam chamber and the infill well. The infill well is then produced by a gravity controlled recovery process. Unfortunately, this approach requires additional energy and water input, and may produce additional wastewater.

In view of the foregoing background it is therefore an object of the present invention to provide a method for more efficiently recovering hydrocarbon resources from a subterranean formation and while potentially using less energy and/or water resources and providing faster recovery of the hydrocarbons.

These and other objects, features and advantages of the present invention are provided by a method for hydrocarbon resource recovery in a subterranean formation comprising forming a plurality of spaced apart injector/producer well pairs in the subterranean formation, with each injector/producer well pair comprising a laterally extending producer well and a laterally extending injector well spaced thereabove. The method also includes forming a plurality of laterally extending infill wells in the subterranean formation, with each infill well being located between respective adjacent injector/producer well pairs. Further, the method includes recovering hydrocarbon resources from the producer wells based upon Steam Assisted Gravity Drainage (SAGD) via the injector/producer well pairs. In addition, the method includes recovering hydrocarbon resources from the infill wells based upon RF heating regions of the subterranean formation surrounding the respective infill wells. Accordingly, the hydrocarbon resources in the wedge region between adjacent injector/producer well pairs can be recovered. In addition, less overall energy may be used to heat the formation, and less water may be used in the recovery process. Faster oil recovery can also be achieved.

In particular, recovering hydrocarbon resources from the producer wells based upon SAGD typically creates a respective steam chamber associated with each injector/producer well pair. Accordingly, recovering hydrocarbon resources from the infill wells based upon RF heating may comprise creating hydraulic communication between each pair of adjacent steam chambers and an associated infill well therebetween. Moreover, recovering hydrocarbon resources from the infill wells based upon RF heating may further comprise using SAGD to provide pressure support in the regions of the subterranean formation surrounding the infill wells.

The RF heating may be delivered from the infill wells themselves. More particularly, the method may include positioning at least one respective RF antenna within each of the infill wells, and wherein the RF heating comprises supplying RF energy to the RF antennas.

In a typical arrangement, each infill well may be positioned midway between respective adjacent injector/producer well pairs. In addition, each infill well may be positioned below a level of respective adjacent injector wells and closer to a level of adjacent producer wells.

The method may further comprise using a steamflood drive after using SAGD to recover further hydrocarbon resources. The subterranean formation may comprise an oil sand formation, for example.

FIG. 1 is a flowchart for the method in accordance with the invention.

FIG. 2 is a schematic cross-section of a portion of a hydrocarbon bearing subterranean formation in accordance with the present invention.

FIG. 3 is a schematic cross-section similar to FIG. 2 and shown at a later time during the hydrocarbon recovery process.

FIGS. 4A and 4B are schematic diagrams illustrating simulations of the expanding steam chambers at different times using the method in accordance with the invention.

FIGS. 4C and 4D are schematic diagrams illustrating simulations of the expanding steam chambers at different times using only conventional SAGD as in the prior art.

FIG. 5 is a graph of cumulative oil recovery versus time for various simulated embodiments of the method in accordance with the present invention and compared against a simulation using only conventional SAGD as in the prior art.

FIG. 6 is a graph of energy usage versus cumulative oil recovered for a simulated embodiment of the method in accordance with the invention.

FIG. 7 is a graph of energy usage versus cumulative oil recovered for a simulated embodiment of using only conventional SAGD as in the prior art.

FIG. 8 is a graph of water-to-oil ratio versus cumulative oil recovered for a simulated embodiment of the method in accordance with the invention.

FIG. 9 is a graph of water-to-oil ratio versus cumulative oil recovered for a simulated embodiment of using only conventional SAGD as in the prior art.

FIG. 10 is a table of comparative results of simulations of an embodiment of the method of the present invention and using only conventional SAGD as in the prior art.

The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which preferred 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 illustrated 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.

Referring now initially to the flowchart **20** of FIG. 1, and the schematic cross-sectional views of the subterranean formation **40** as shown in FIGS. 2-3, method embodiments of the invention are now described. From the start (Block **22**) the method is for hydrocarbon resource recovery in a subterranean formation **40** and comprises, at Block **24**, forming a plurality of spaced apart injector/producer well pairs **41a, 42a, 41b, 42b** in the subterranean formation. As shown in the illustrated embodiment, the subterranean formation **40** includes a payzone **45** between an underburden layer **46** and an overburden layer **47**, as will be appreciated by those skilled in the art. The subterranean formation **40** may comprise an oil sand formation, for example. A typical payzone **45** may be 15 to 30 meters in thickness, for example. The overall field may occupy a region of one by twenty kilometers, for example, although other sizes are also possible.

The first injector/producer well pair comprises a laterally extending producer well **42a** and a laterally extending injector well **41a** spaced thereabove. A typical vertical spacing may be about 5 meters, for example. Similarly, the second injector/producer well pair comprises a laterally extending producer well **42b** and a laterally extending injector well **41b** spaced thereabove. Of course, in a typical subterranean formation there may be hundreds of pairs of injector and producer wells spaced throughout the payzone **45**.

At Block **26,** a plurality of laterally extending infill wells **43** are formed in the payzone **45** of the subterranean formation **40**, with each infill well being located between respective adjacent injector/producer well pairs in the so-called wedge region **44**. A typical lateral spacing is 50 meters from the infill well **43** to each adjacent injector producer well pair. In other embodiments, more than one infill well **43** may be provided between respective adjacent injector/producer well pairs as will be appreciated by those skilled in the art.

Further the method includes recovering hydrocarbon resources from the producer wells **42a, 42b** based upon Steam Assisted Gravity Drainage (SAGD) via the injector/producer well pairs (Block **28**). In addition, the method includes at Block **30** recovering hydrocarbon resources from the infill wells **43** based upon RF heating regions of the payzone **45** of the subterranean formation **40** surrounding the respective infill wells before stopping at Block **32**. Thus, the hydrocarbon resources in the wedge region **44** between adjacent injector/producer well pairs **42a, 41a, 42b, 41b** can be recovered. Although Blocks **28** and **30** are illustrated as separate steps for clarity of explanation in the flowchart **20** they are typically performed at a same time as will be appreciated by those skilled in the art. And, as will be described in greater detail below, less overall energy may be used to heat the formation **40**, and less water may be used in the recovery process.

In particular, recovering hydrocarbon resources from the producer wells **42a, 42b** based upon SAGD illustratively creates a respective growing steam chamber **53a, 53b** associated with each injector/producer well pair **41a, 42a, 41b, 42b** as seen perhaps best in FIG. 3. In some embodiments, the two steam chambers **53a, 53b** may eventually join together in an upper middle region above the wedge region **44**.

As will be appreciated by those skilled in the art, the RF energy radiated from the antenna **51** into the surrounding portions of the infill well **43** heats these portions and advantageously creates hydraulic communication between the pair of adjacent steam chambers **53a, 53b** and the infill well **43** therebetween. In slightly different terms, recovering hydrocarbon resources from the infill well **43** based upon RF heating may further comprise using SAGD to provide pressure support in the region of the subterranean formation surrounding the infill well. For purposes of illustration, arrows **54a, 54b** indicate a direction of the gravity drive oil path in each respective steam chamber **53a, 53b**; and arrows **55a, 55b** indicate the steamflood drive oil path toward the infill well **43** as will be appreciated by those skilled in the art.

In the illustrated embodiment, the RF heating is delivered from the antenna **51** within the infill well **43**. This is a particularly advantageous arrangement, since only the infill well **43** need be drilled which can serve to facilitate the antenna positioning and which can also be used as a producer for the wedge region **44** via a coaxial arrangement. In other embodiments, it may be desirable to position one or more RF antennas differently in the subterranean formation **40** so long as heat can be effectively provided to at least the regions surrounding the infill well **43** so that oil can be recovered from the wedge region **44**. Accordingly, the method may include positioning at least one respective RF antenna **51** within each infill well in the payzone **45** of the subterranean formation **40**, and supplying RF energy from the RF source **50** to the RF antenna **51**. Those of skill in the art will appreciate the construction and operation of the antenna **51** and RF source **50** without requiring further discussion herein.

The RF heating mobilizes the oil between adjacent steam chambers **53a, 53b** and the infill well **43**; establishes hydraulic communication between the chambers and the infill well; allows oil to drain to the infill well via gravity drainage with pressure support from the steam chambers; and later in the well's life, steamflood can provide additional drive to recover unproduced by gravity drainage. The steamflood drive is a displacement drive, not a gravity drive, therefore, the recovery rates are less affected by the thickness of the payzone **45**.

In a typical arrangement as shown in FIGS. 2 and 3, each infill well **43** may be positioned midway between respective adjacent injector/producer well pairs **41a, 42a, 41b, 42b**. Each infill well **43** may also be positioned below a level of respective adjacent injector wells **41a, 41b** and closer to a level of adjacent producer wells **42a, 42b**.

As will be appreciated by those skilled in the art, in some instances the RF heating may be started prior to the injection of steam into the injector wells **41a, 41b**, while in other embodiments the RF heating may be performed simultaneously with or after the injection of steam into the injector wells **41a, 41b**. In addition, once hydraulic communication is established it may be desirable to turn off the RF heating to thereby save energy.

The injection of steam through a single well may sometimes be difficult due to low fluid injectivity of a cold formation and the desire to maintain a sufficiently low pressure so as to avoid fracturing the adjacent formation structure. Accordingly, steam is typically injected cyclically into a traditional steam well. The significant advantage of using RF heating in the wedge region **44**, in particular, is that the RF energy input does not need cycling since the RF energy is basically absorbed as heat by the water or moisture in the surrounding areas. The RF heating effectively and efficiently establishes hydraulic communication with the infill well **43** by heating the oil to a sufficient temperature. This hydraulic communication permits pressure support from the steam chambers **53a, 53b** to encourage the flow of oil from the payzone **45** into the infill well **43**. Heating of the wedge region **44** using other techniques such as with gas or water injection may not be effective because of the relatively low injectivity as will be appreciated by those skilled in the art.

With the additional of heat from the input of RF energy, the energy input requirement for the steam for SAGD may also be reduced. Accordingly, the combination of SAGD and RF heating provides efficient use of electrical and other energy inputs.

In some embodiments, the infill wells **43** can be added after SAGD has been performed on the payzone **45**; however, in such embodiments the ground may already be heated which may make well boring more difficult. Accordingly, it is typically more beneficial to form the infill wells **43** at the same time the other wells **41a, 41b, 42a, 42b** are being formed in the payzone **45** of the subterranean formation **40**. The production of hydrocarbon resources also from the wedge regions **44** provides more efficient use of the available land area available. In some embodiments, an RF susceptor in addition to water, could be added to the payzone **45** to convert the RF energy into heat as will be appreciated by those skilled in the art.

The typical timescale of recovery using SAGD alone is typically largely determined by the reservoir conditions and the payzone **45** thickness, with thicker being better. There have been few ways to accelerate recovery using SAGD. There may be a high heat loss to the overburden layer **47** due to the relatively long production cycle. There may also be startup issues and water usage raises potential environmental and cost concerns.

In contrast to SAGD alone, the combination of SAGD and RF heating in the regions surrounding the infill wells **43** significantly reduces the time it takes to recover the oil by as much as two times. Energy and water usage are both reduced. And the approach is applicable to both thick and thin payzones **45**.

Referring now to FIGS. 4A-4D, a comparison of the described embodiments versus traditional SAGD alone is now explained. More particularly, FIG. 4A shows a simulation of the steam chamber progress after three months using the combined SAGD and RF infill heating of the present invention, and FIG. 4B shows the simulation after three years. In contrast, FIG. 4C shows a simulation of steam chamber progress based upon conventional SAGD alone, and FIG. 4D continues that simulation at three years. It can be readily seen that the steam chamber has progressed significantly further in accordance with the invention at the six month date.

The advantage in cumulative oil recovery is now explained with reference to the plots in FIG. 5. The horizontal plot **60** is at a 70% of the original oil-in-place (OOIP) for a simulation of a five meter length axial segment of a well. Full scale well results can be extrapolated by using a ratio of the well length to the five meter length simulation. For the five meter length simulation domain, there was a 1200 m^3 OOIP. Plot **66** represents simulated recovery of oil using only SAGD. The other plots are for SAGD plus RF heating (at 200 Khz) for nine months **61**, twelve months **62**, fifteen months **63**, twelve months **64**, and twenty-one months **65**. Again it can be seen that the recovery is accelerated compared to conventional SAGD alone, and the RF heating permits trading of RF energy costs versus recovery time.

Referring now additionally to the comparative graphs of FIGS. 6 and 7, further advantages of the invention are now described. FIG. 6 shows a plot of RF energy input per barrel of recovered oil **71**, along with the steam energy input **72** and the total energy input **73**, with the 70% OOIP value indicated by the vertical line **74**, and these are also for the five meter length axial segment simulation. FIG. 7 shows a corresponding plot of the total energy input **75** for a convention SAGD process alone, and vertical line **76** is the 70% OOIP value. From these comparisons, it can be seen that the SAGD plus RF infill heating uses 1.35 GJ/bbl at a 70% recovery for the five meter length axial segment simulation, while conventional SAGD along uses 1.94 GJ/bbl; and the RF infill has a relatively low electricity energy requirement of 0.11 GJ/bbl.

With reference to the plots in FIGS. 8 and 9, comparative water usage for the five meter length axial segment simulation for the present invention is now described. The water-to-oil ratio for the invention is given by plot **81** and the steam-to-oil ratio is given by plot **82**, while the 70% OOIP value is given by plot **83** of FIG. 8. In contrast, the water-to-oil ratio for the use of conventional SAGD only is given by plot **85** and the steam-to-oil ratio is given by plot **84**, while the 70% OOIP value is given by plot **86** of FIG. 9. The water–to-oil-ratio for the method including SAGD plus the RF heating as in the invention is 2.9 at 70% OOIP, and the corresponding value is 4.5 for SAGD alone.

In summary, for the simulations described herein for a fifteen meter payzone thickness in a subterranean formation, for a normalized recovery time of one for a conventional SAGD process, the corresponding recovery time for the SAGD and RF heating of the invention reduces the normalized time down to 0.54. Along these lines for a water-to-oil ratio of 4.5 for a conventional SAGD process, the corresponding ratio for the SAGD and RF heating of the invention is reduced down to 2.9. Continuing the comparisons of interest, for an energy input of 1.94 GJ/bbl for a conventional SAGD process, the corresponding energy input for the SAGD and RF heating of the invention is reduced down to 1.36. And lastly, the RF energy used by the invention is only 0.11 GJ/bbl. These values are shown in the table of FIG. 10.

CLAIMS

1. A method for hydrocarbon resource recovery in a subterranean formation comprising:

forming a plurality of spaced apart injector/producer well pairs in the subterranean formation, each injector/producer well pair comprising a laterally extending producer well and a laterally extending injector well spaced thereabove;

forming a plurality of laterally extending infill wells in the subterranean formation, each infill well being located between respective adjacent injector/producer well pairs; and

recovering hydrocarbon resources from the producer wells based upon Steam Assisted Gravity Drainage (SAGD) via the injector/producer well pairs; and

recovering hydrocarbon resources from the infill wells based upon RF heating regions of the subterranean formation surrounding the respective infill wells.

2. The method according to Claim 1 wherein recovering hydrocarbon resources from the producer wells based upon SAGD creates a respective steam chamber associated with each injector/producer well pair; and wherein recovering hydrocarbon resources from the infill wells based upon RF heating comprises creating hydraulic communication between each pair of adjacent steam chambers and an associated infill well therebetween.

3. The method according to Claim 1 wherein recovering hydrocarbon resources from the infill wells based upon RF heating further comprises using SAGD to provide pressure support in the regions of the subterranean formation surrounding the infill wells.

4. The method according to Claim 1 wherein the RF heating is delivered from the infill wells.

5. The method according to Claim 1 further comprising positioning at least one respective RF antenna within each of the infill wells; and wherein RF heating comprises supplying RF energy to the RF antennas.

6. The method according to Claim 1 wherein each infill well is positioned midway between respective adjacent injector/producer well pairs.

7. The method according to Claim 1 wherein each infill well is positioned below a level of respective adjacent injector wells.

8. The method according to Claim 1 further comprising using steamflood drive after using SAGD to recover further hydrocarbon resources.

9. The method according to Claim 1 wherein the subterranean formation comprises an oil sand formation.

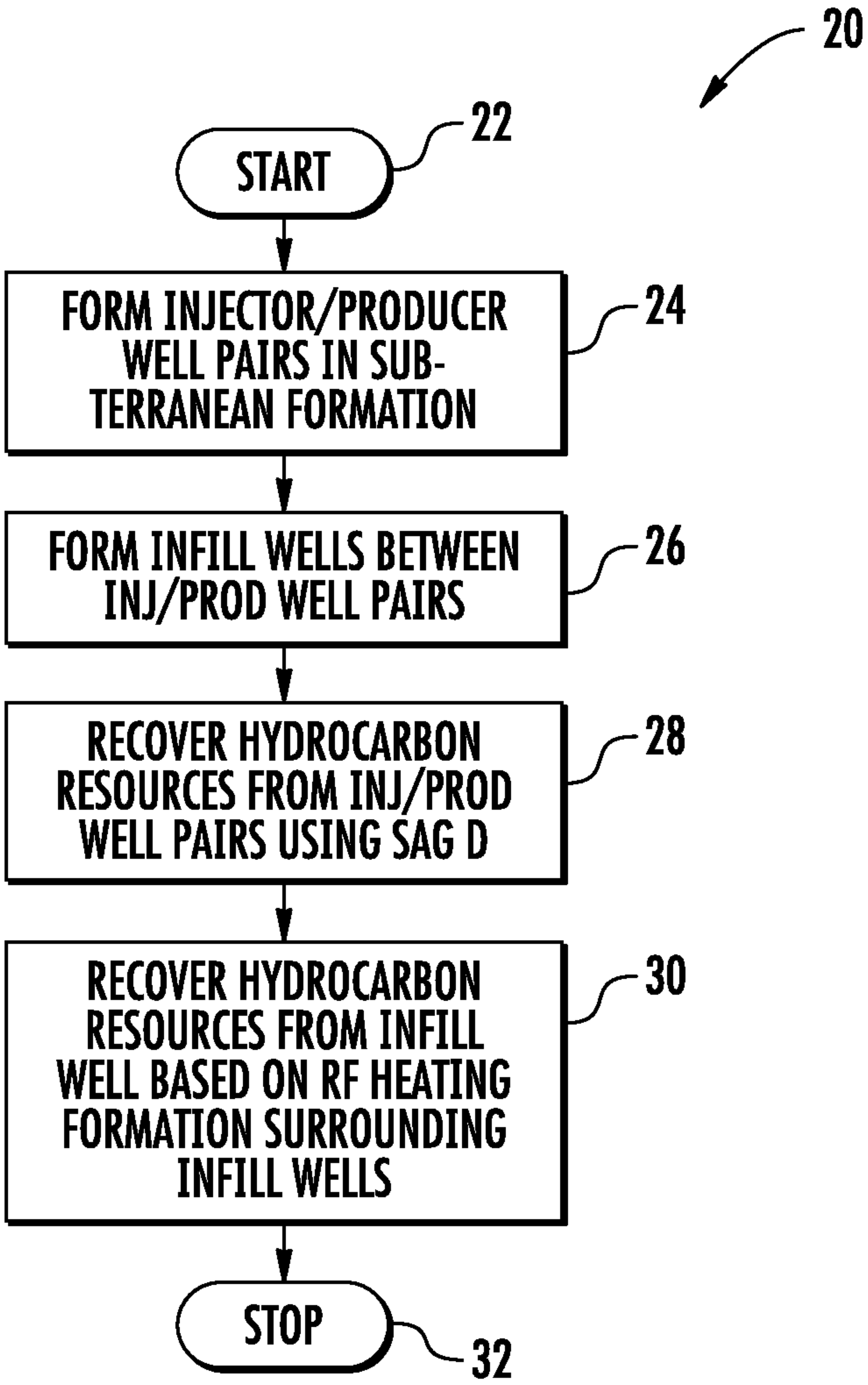
20
START
22
FORM INJECTOR/PRODUCER WELL PAIRS IN SUB-TERRANEAN FORMATION
24
FORM INFILL WELLS BETWEEN INJ/PROD WELL PAIRS
26
RECOVER HYDROCARBON RESOURCES FROM INJ/PROD WELL PAIRS USING SAG D
28
RECOVER HYDROCARBON RESOURCES FROM INFILL WELL BASED ON RF HEATING FORMATION SURROUNDING INFILL WELLS
30
STOP
32

FIG. 1

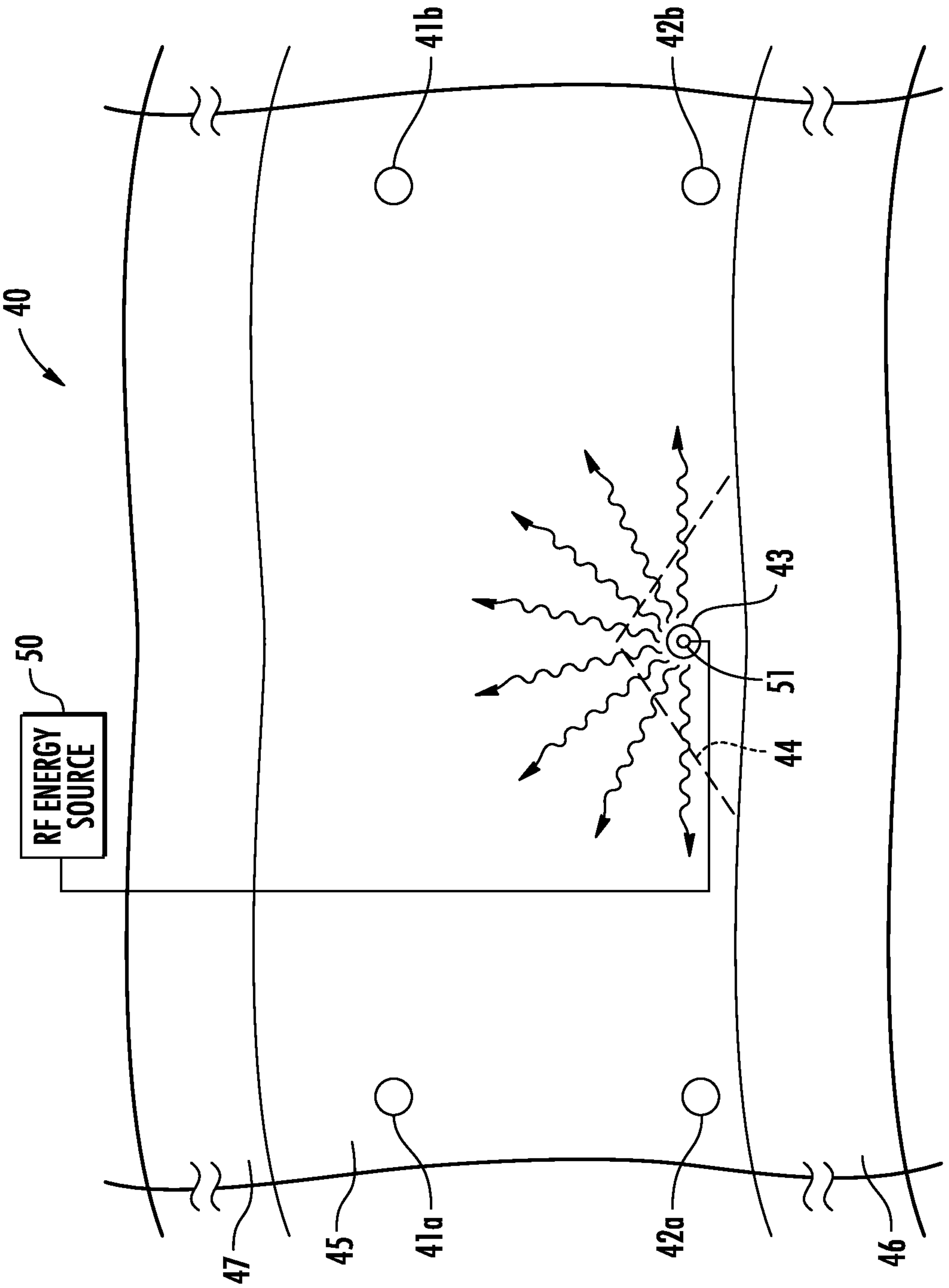

FIG. 2

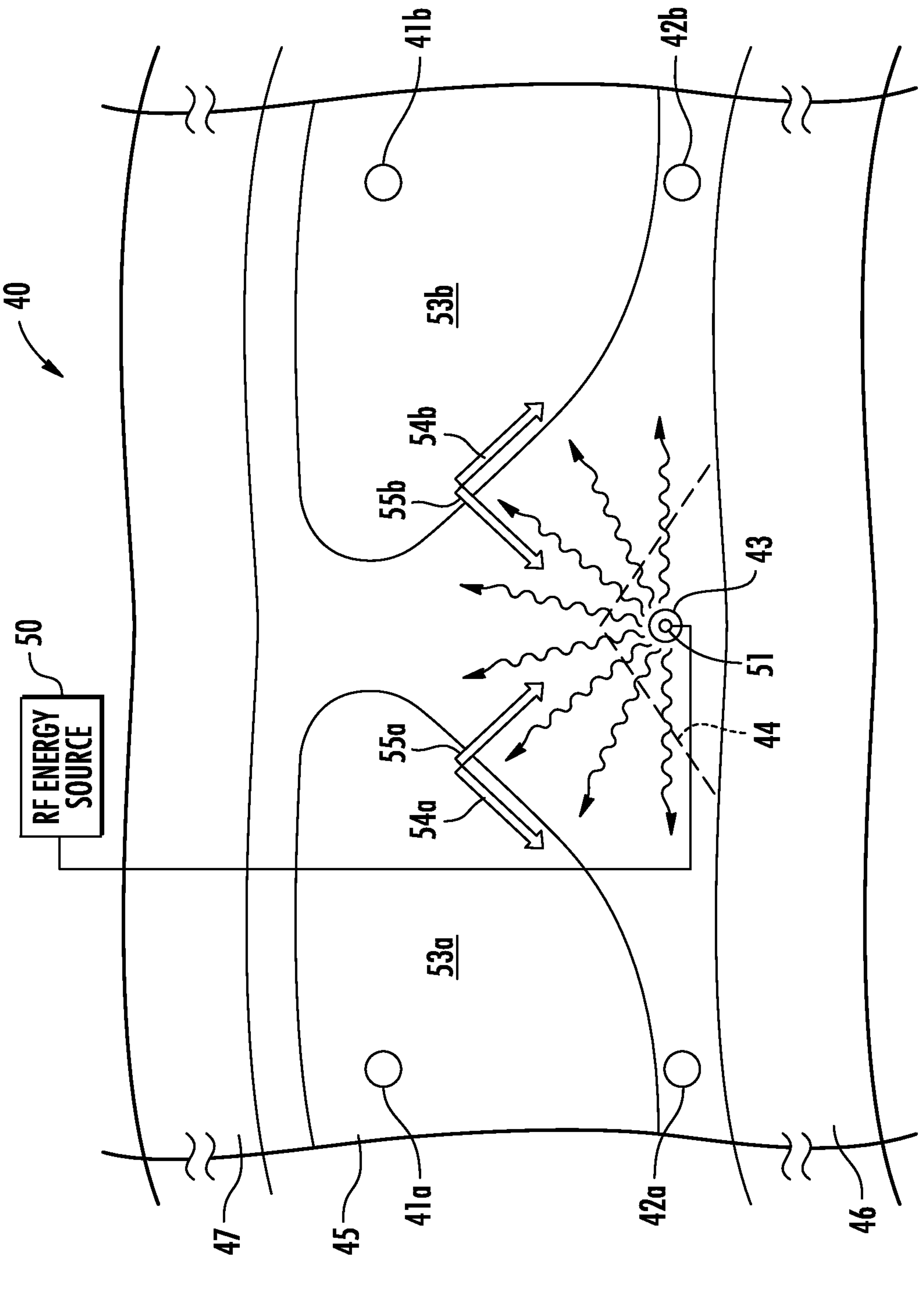
40
RF ENERGY SOURCE
50
41b
42b
53b
54b
55b
43
51
44
55a
54a
53a
41a
42a
45
47
46

FIG. 3

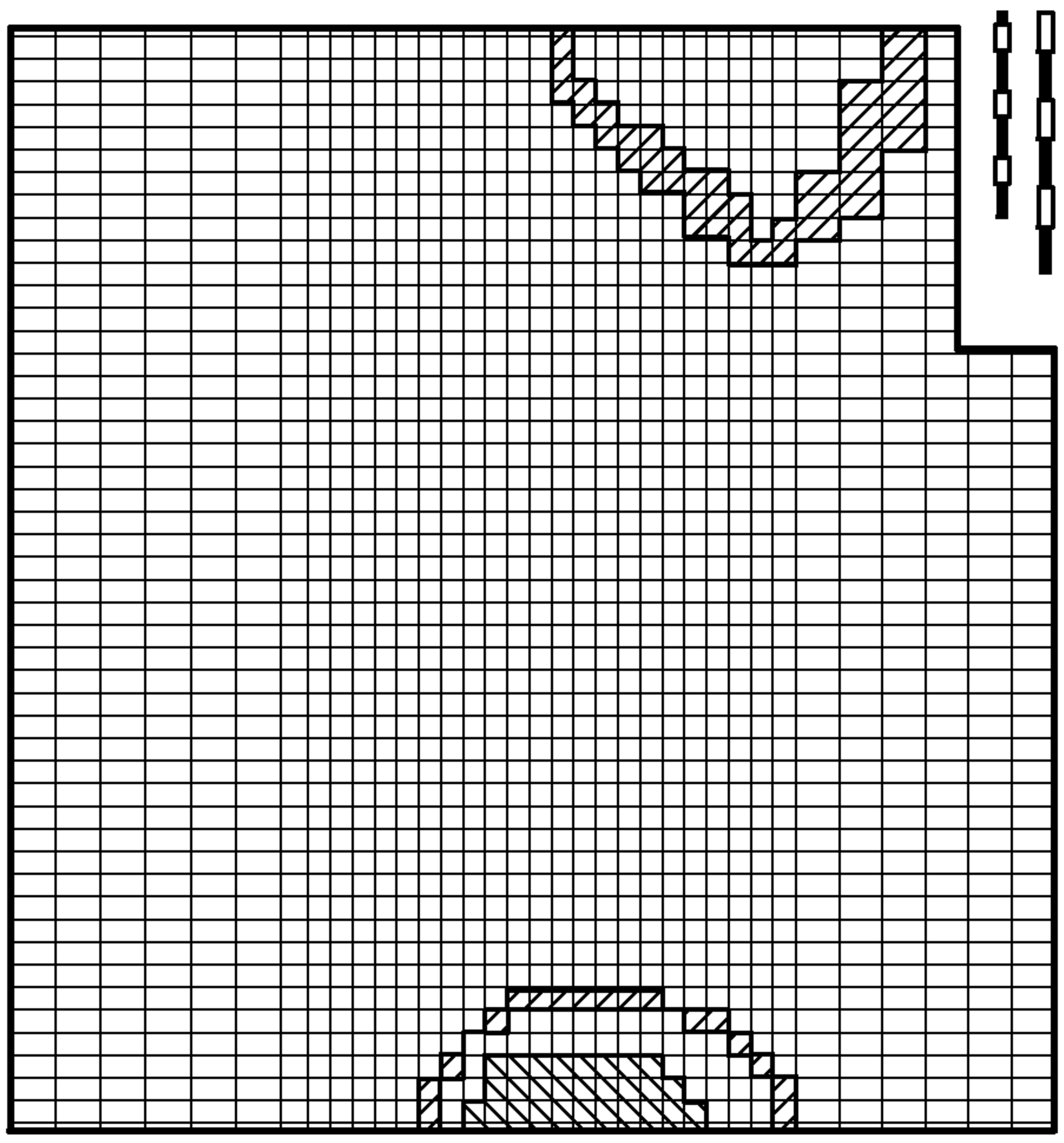

FIG. 4A

FIG. 4B

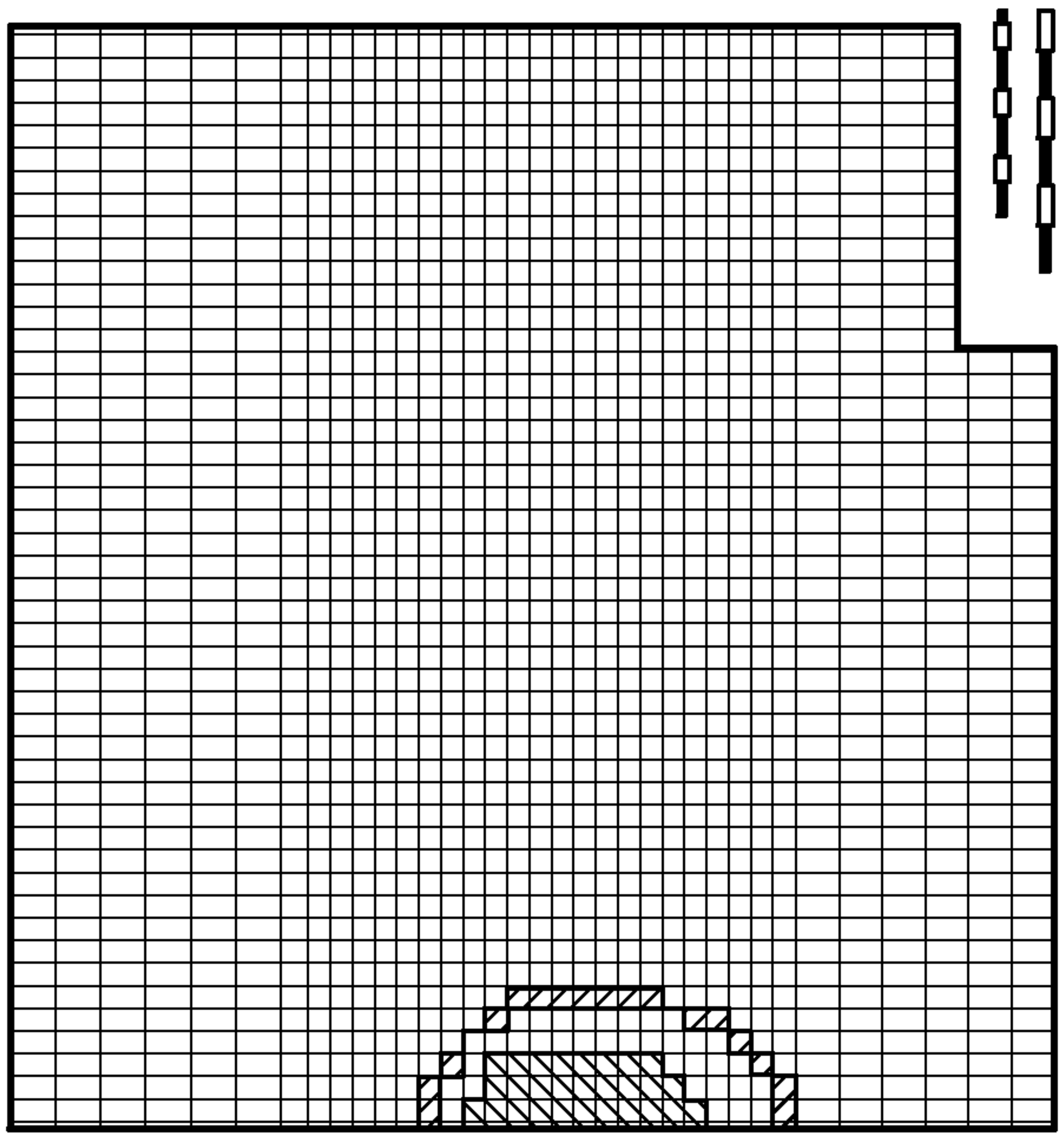

FIG. 4C
PRIOR ART

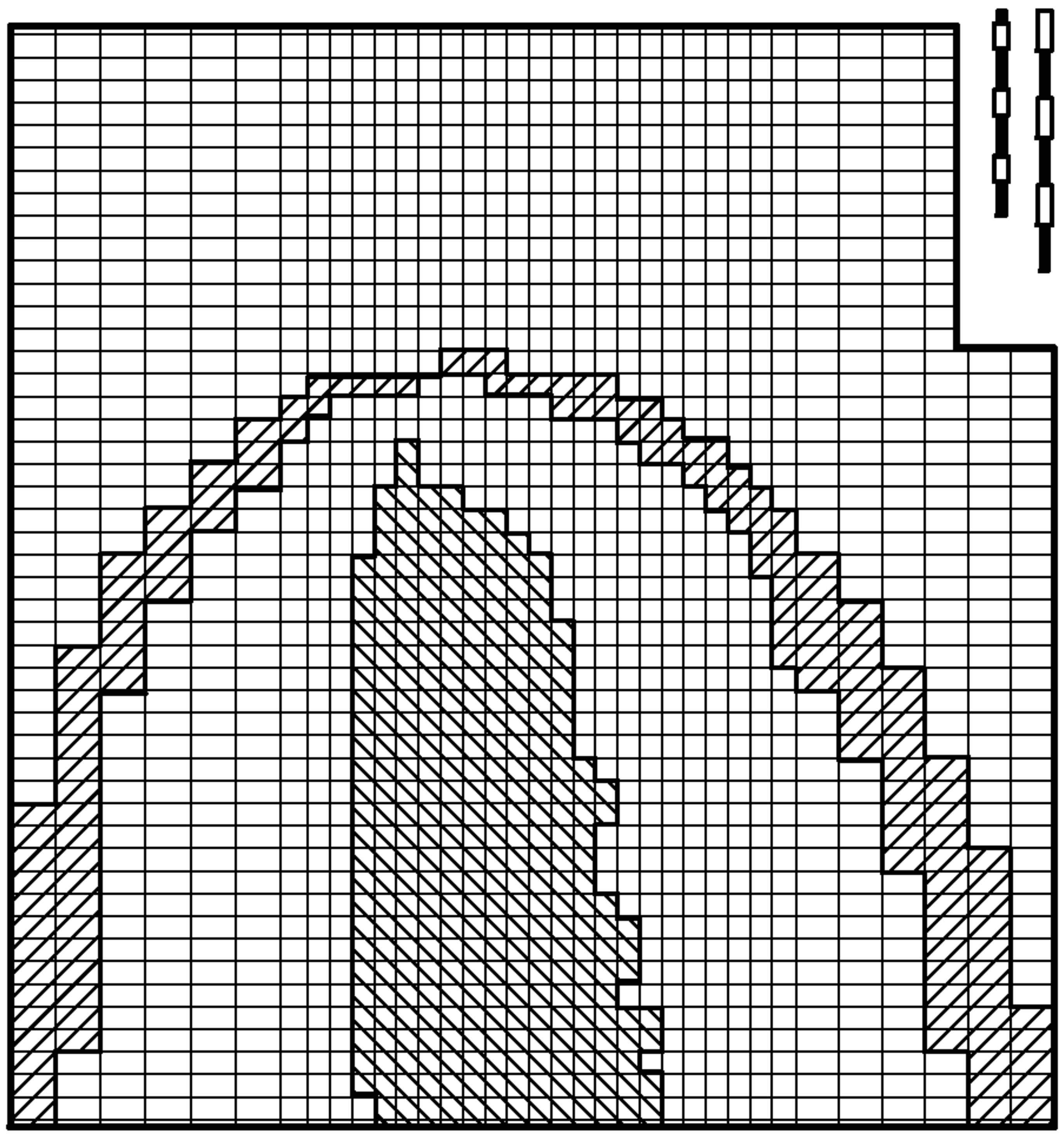

FIG. 4D
PRIOR ART

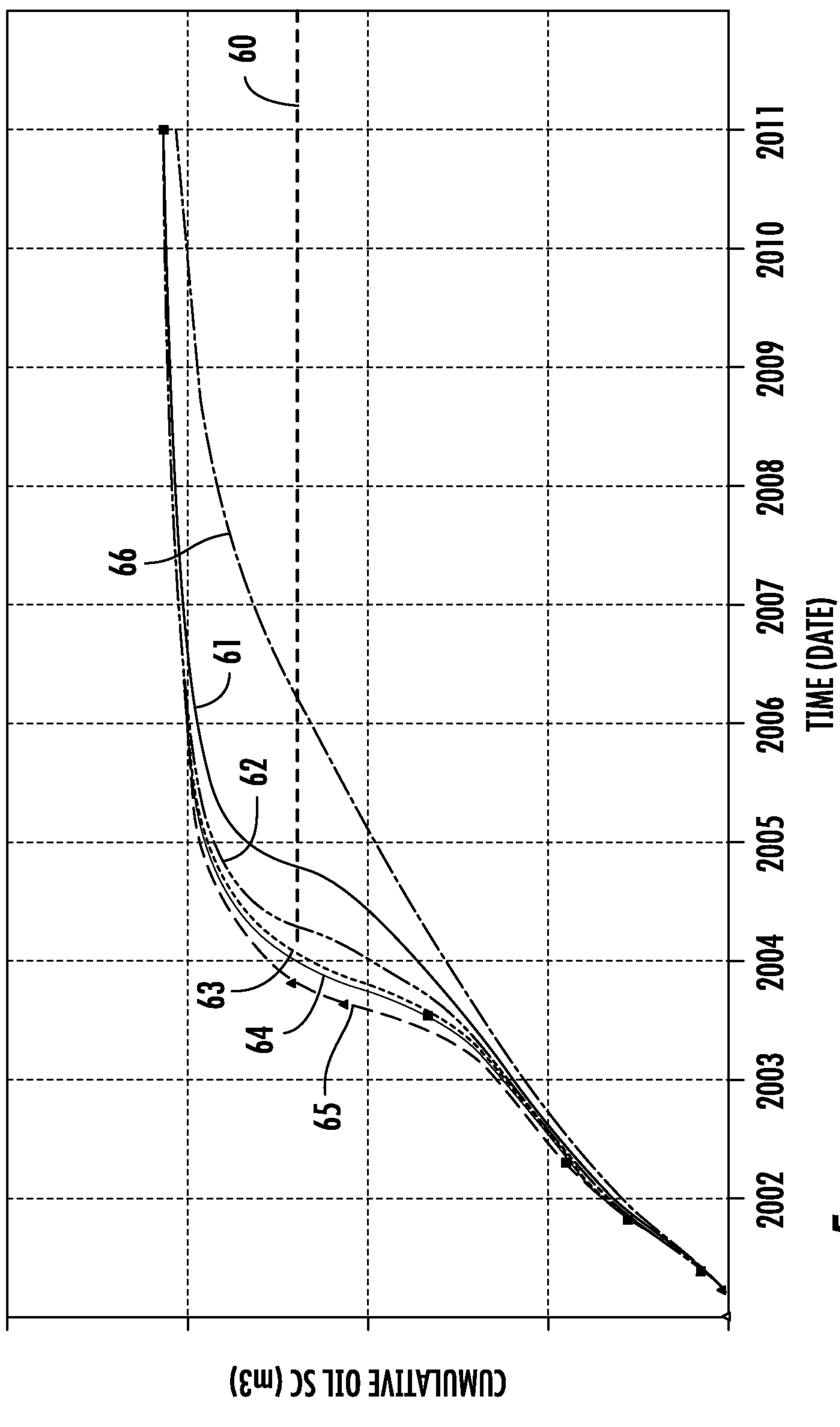
CUMULATIVE OIL SC (m3)
TIME (DATE)
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
60
61
62
63
64
65
66

FIG. 5

6/8

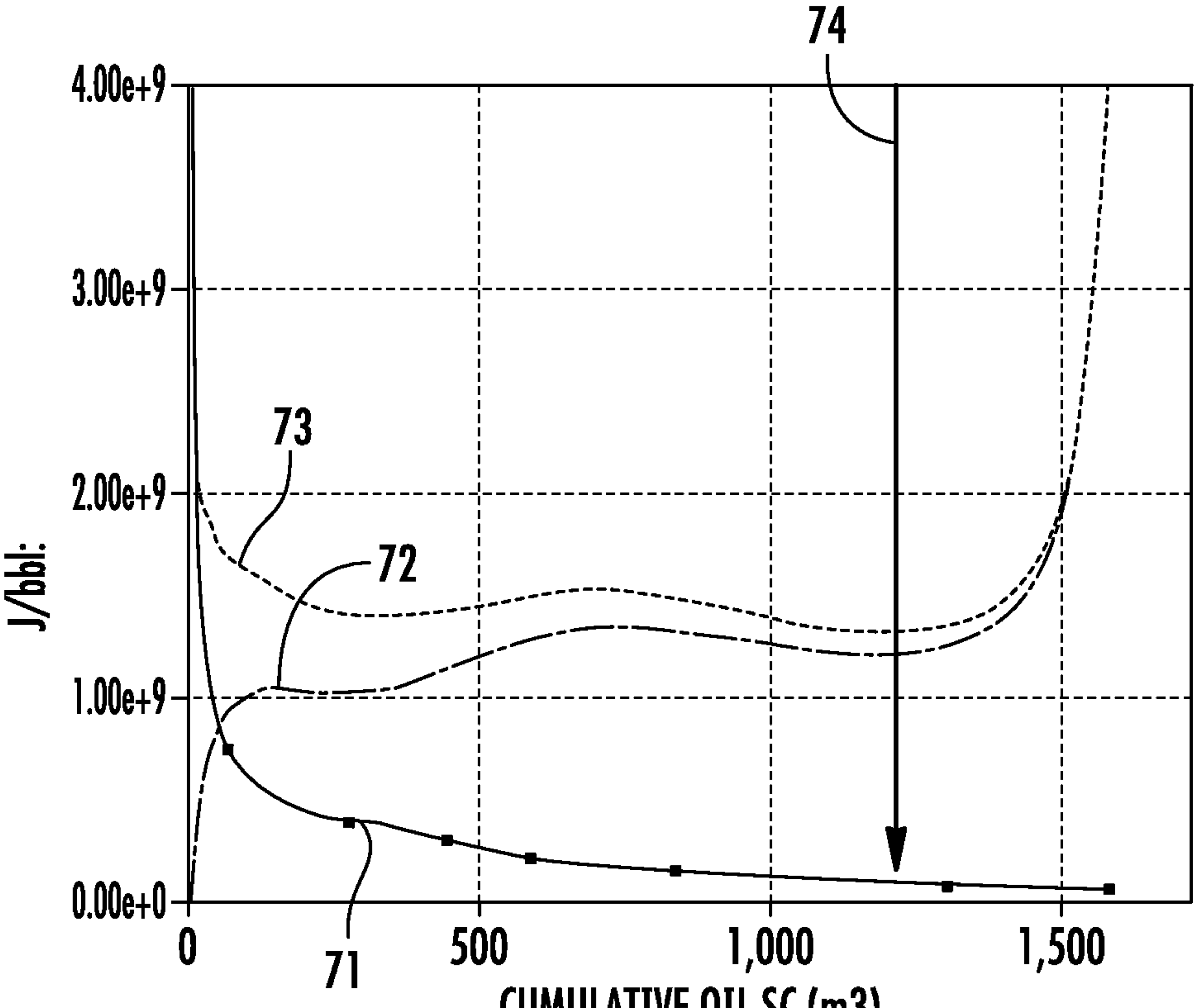

FIG. 6

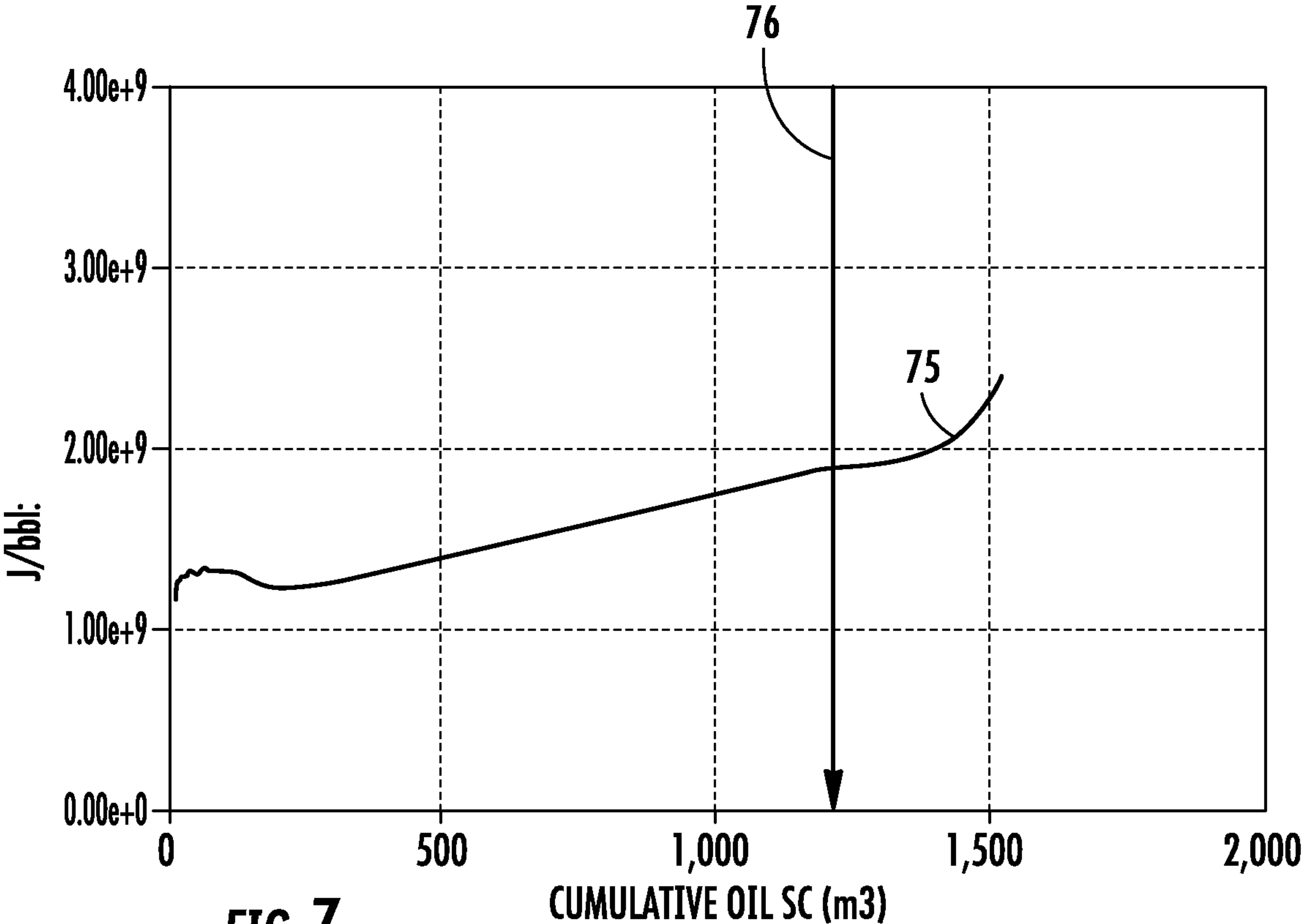

FIG. 7
PRIOR ART

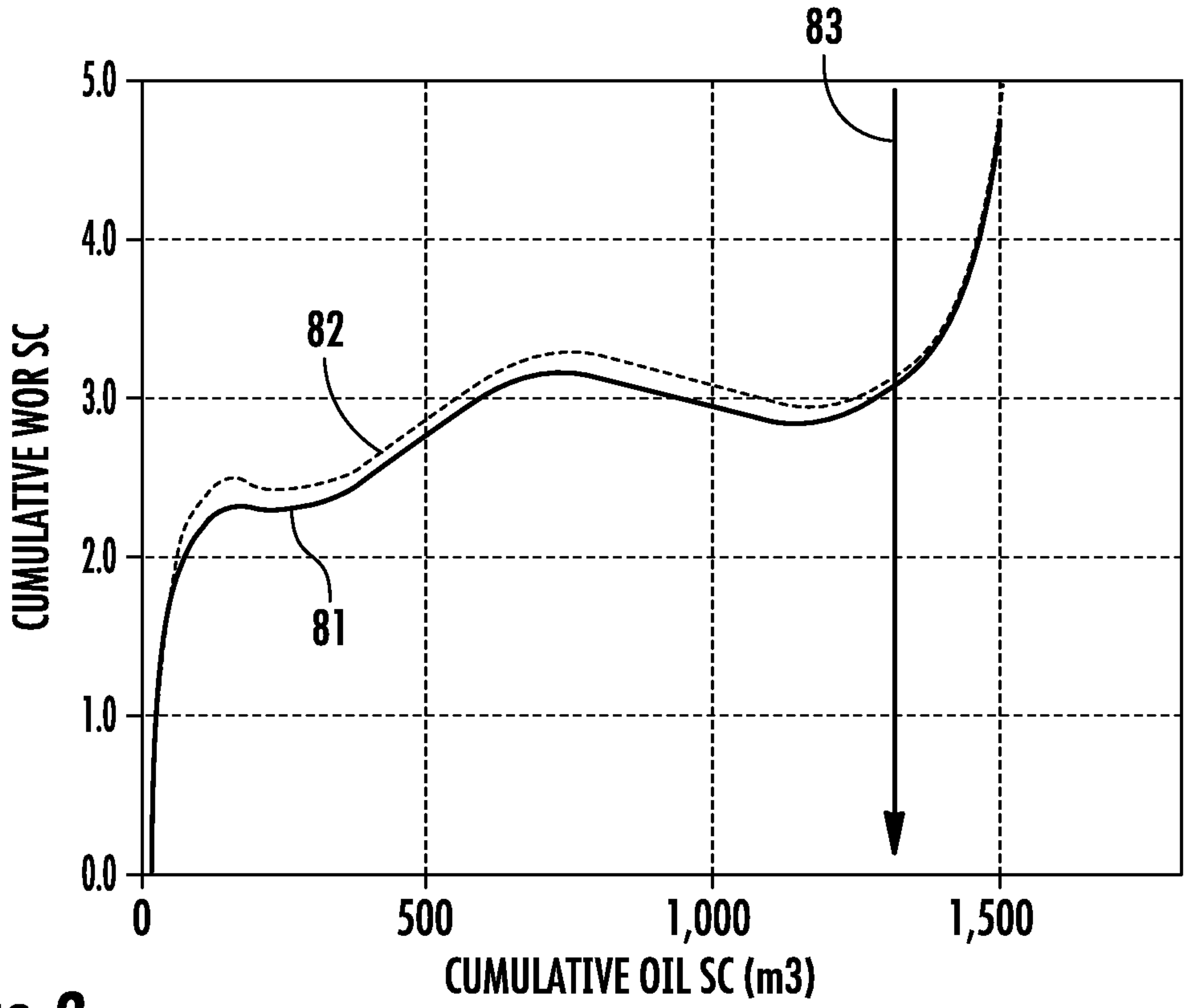

FIG. 8

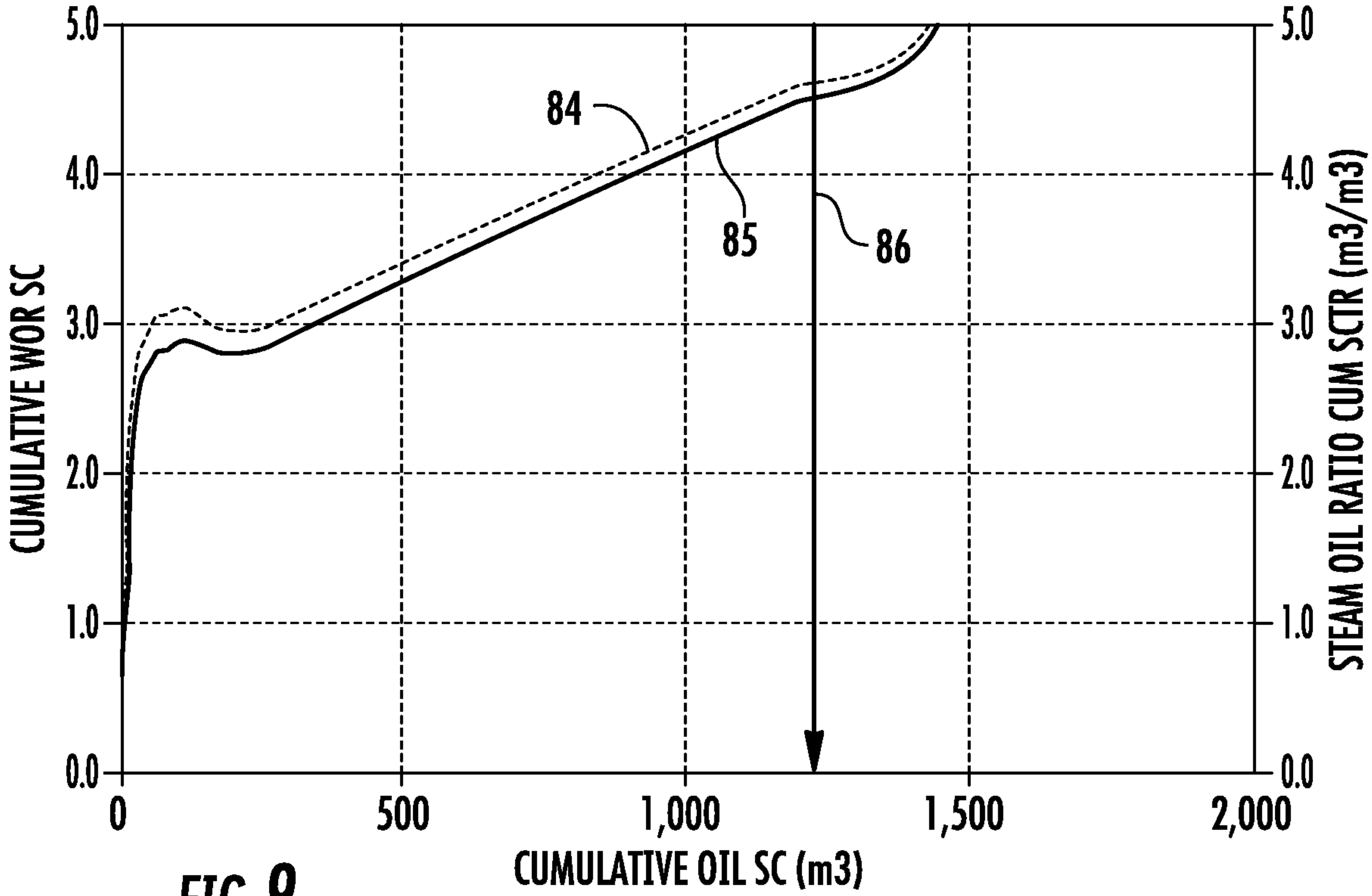

FIG. 9
PRIOR ART

15 M PAYZONE

	NORMALIZED RECOVERY TIME	WOR	TOTAL (GJ/bbl)	RF (GJ/bbl)
SAGD	1	4.5	1.94	N/A
RF/INFILL+SAGD	0.54	2.9	1.36	0.11

FIG. 10

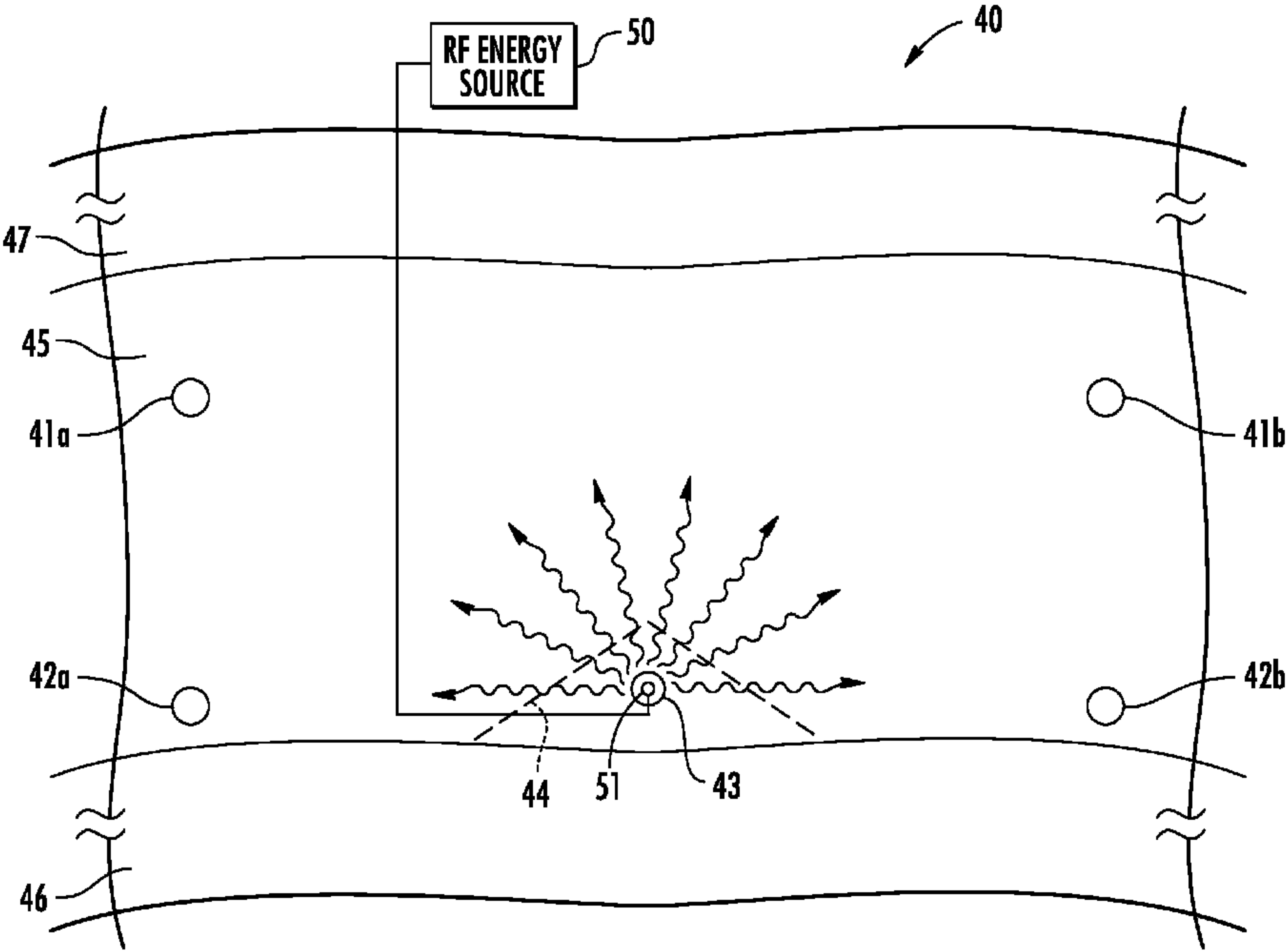

FIG. 2