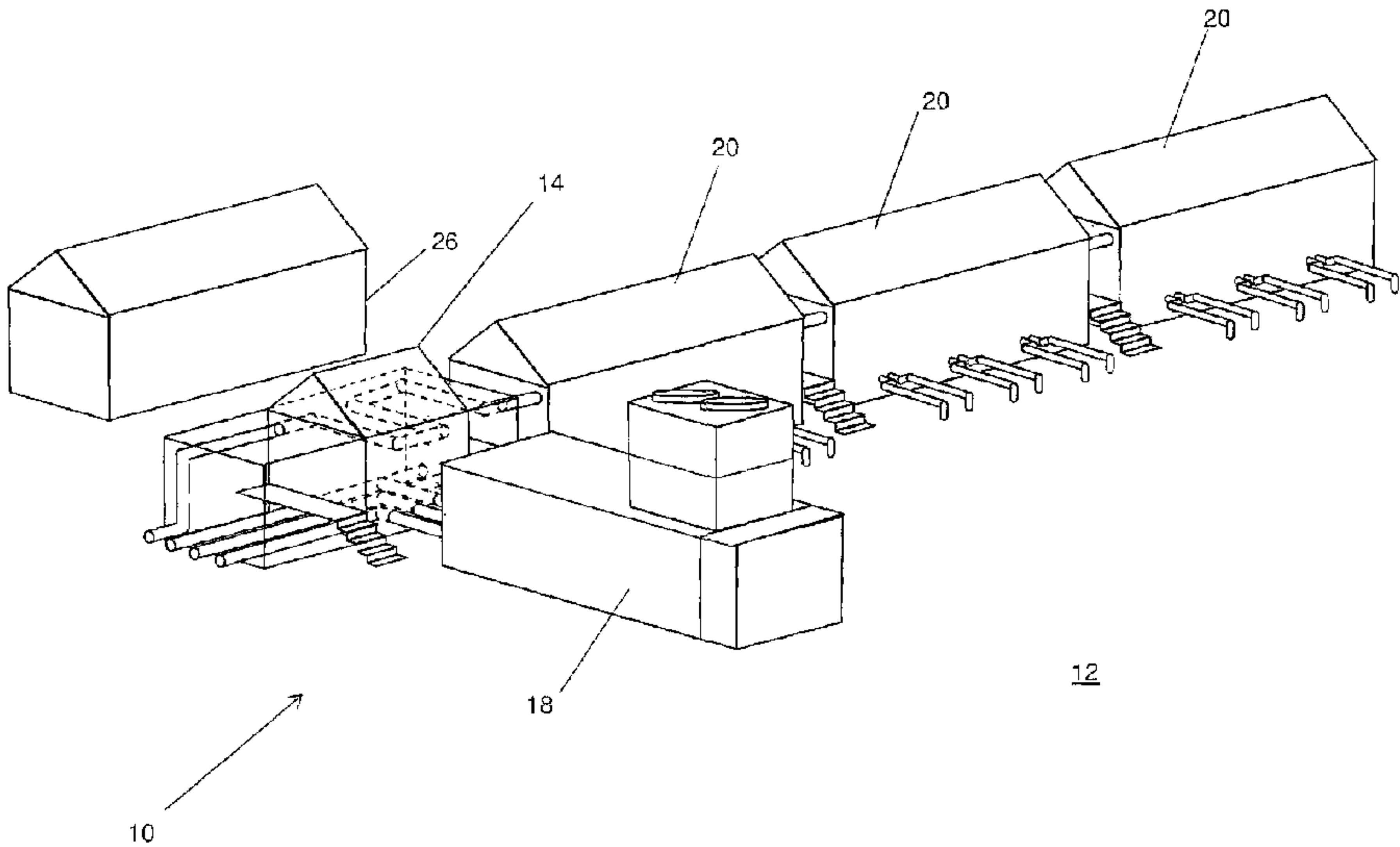




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POUR LA RECUPERATION DU BITUME
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(57) **Abrégé/Abstract:**

A start-up module used during a start-up phase in a steam assisted gravity drainage (SAGD) process, is provided, which includes a transportable frame that can be detachably coupled to operating facilities at a Well pad site. The operating facilities at the well pad site include a steam line for providing steam to one or more wells, a fuel gas line for providing fuel gas to one or more wells, an emulsion line for transporting production fluids to a processing facility, and a production gas line for transporting production gas to the processing facility. The transportable frame includes and supports start-up operations equipment. A steam separator, a condensate separator, a cooler, at least one pump, and at least one controller are supported by the transportable frame to temporarily configure the operating facilities to implement the start-up phase and be collectively removable from the well pad site thereafter.

ABSTRACT

A start-up module used during a start-up phase in a steam assisted gravity drainage (SAGD) process, is provided, which includes a transportable frame that can be detachably coupled to operating facilities at a well pad site. The operating facilities at the well pad site include a steam line for providing steam to one or more wells, a fuel gas line for providing fuel gas to one or more wells, an emulsion line for transporting production fluids to a processing facility, and a production gas line for transporting production gas to the processing facility. The transportable frame includes and supports start-up operations equipment. A steam separator, a condensate separator, a cooler, at least one pump, and at least one controller are supported by the transportable frame to temporarily configure the operating facilities to implement the start-up phase and be collectively removable from the well pad site thereafter.

MODULAR START-UP SYSTEM FOR A WELL PAD USED IN BITUMEN RECOVERY

TECHNICAL FIELD

[0001] The following relates to a modular system for a well pad used in bitumen recovery.

DESCRIPTION OF THE RELATED ART

[0002] Bitumen is known to be considerably viscous, does not flow like conventional crude oil, and can be present in an oil sand reservoir. As such, bitumen is recovered using what are considered non-conventional methods. For example, bitumen reserves are typically extracted from a geographical area using either surface mining techniques, wherein overburden is removed to access the underlying pay (e.g., oil sand ore-containing bitumen) and transported to an extraction facility; or using in situ techniques, wherein subsurface formations (containing the pay) are heated such that the bitumen is caused to flow into one or more wells drilled into the pay while leaving formation rock in the reservoir in place. Both surface mining and in situ processes produce a bitumen product that is subsequently sent to an upgrading and refining facility, to be refined into one or more petroleum products, such as gasoline and jet fuel.

[0003] Bitumen reserves that are too deep to feasibly permit bitumen recovery by mining techniques are typically accessed by drilling wellbores into the hydrocarbon bearing formation (i.e. the pay) and implementing an in situ technology. There are various in situ technologies available, such as steam driven based techniques. These include, for example, Steam Assisted Gravity Drainage (SAGD) and Cyclic Steam Stimulation (CSS). In a typical implementation of the SAGD method, a pair of horizontally oriented wells are drilled into the bitumen reserve, such that the pair of horizontal wells are vertically aligned with respect to each other and separated by a relatively small distance, typically in the order of several meters. The well installed closer to the surface and above the other well is generally referred to as an injection well, and the well positioned below the injection well is referred to as a production well. The injection well and the production well are then connected to various equipment installed at a surface site.

[0004] The equipment installed at the surface site is typically referred to as a "well pad", with one or more well pads often being connected to a central processing facility (CPF) via gathering lines, including lines that provide steam and fuel gas to the well pad sites, and receive produced fluids at the CPF via emulsion and production gas lines.

[0005] A SAGD operation typically begins with a start-up phase in which steam is used to achieve fluid communication between the injection well and the production well, referred to as

an interwell region. This fluid communication allows warmed and less viscous bitumen and connate reservoir water to flow as an emulsion, by gravity, down toward the lower production well, where it can be produced to surface. Completion of a SAGD production well for the start-up phase often includes configurations for steam circulation and/or bullheading.

[0006] Steam circulation can be implemented using a tubing that extends from the surface to the toe of the injection or production well. During steam circulation, steam is injected through the tubing that extends to the toe of the well, and circulates back towards the heel of the well through an annular space between the tubing and a surrounding liner or casing (*i.e.* an annulus). This circulated steam can return to surface via the annulus between the tubing and a second shorter tubing that extends from surface to the heel of the well (*i.e.* in a completion that includes a “long” tubing extending from surface to the toe of the well, and a “short” tubing extending from surface to the heel of the well).

[0007] Bullheading can be implemented by injecting steam into the well using the tubing that extends to the toe, both the tubing extending to the toe and an annulus (such as that provided using a short tubing), or via a single steam supply tubing that can be provided down the well. In a bullheading configuration, steam is injected into the reservoir, without any return path to surface. In some implementations, when only a long tubing is used to inject steam into the reservoir, the short tubing or annulus can be blocked to remove such a return path. The use of steam circulation, bullheading, or both, can depend on the characteristics of the reservoir.

[0008] After the start-up phase is completed, which can typically take about three months for a SAGD well pair, the production well can be recompleted for mechanical lift, *e.g.*, by installing a pump to provide hydraulic force for lifting produced fluids to the surface. The injection well can also be recompleted to enable steam to be injected using, for example, both a long tubing and a short tubing.

[0009] To reduce the cost of installing equipment at the well pad sites, various attempts have been made to pre-construct and pre-assemble interconnected components prior to installing the equipment at the site. For example, modular structures have been used to pre-assemble the operating equipment used near the wells, including pipe rack and well operating modules. This avoids at least some of the installation steps and labour required on-site. While these modular structures provide some cost and time/effort savings, there can continue to be significant costs associated with assembling equipment at a well pad site.

SUMMARY

[0010] In one aspect, there is provided a module to be used during a start-up phase in a steam assisted gravity drainage (SAGD) process, the module comprising a transportable frame to be detachably coupled to operating facilities at a well pad site, the transportable frame supporting start-up operations equipment for implementing the start-up phase; wherein the start-up operations equipment are supported by the transportable frame to temporarily configure the operating facilities to implement the start-up phase and be removable from the well pad site thereafter.

[0011] In an implementation, the operating facilities at the well pad site comprise at least a first flow line for providing steam to one or more wells, a second flow line for providing fuel gas to one or more wells, a third flow line for transporting production fluids to a processing facility, and a fourth flow line for transporting production gas to the processing facility.

[0012] In an implementation, the first flow line can correspond to a steam line, the second flow line can correspond to a fuel gas line, the third flow line can correspond to an emulsion line, and the fourth flow line can correspond to a production gas line.

[0013] In an implementation, the start-up operations equipment can comprise: a steam separator detachably coupled to: the fourth flow line configured to transport start-up fluids comprising steam vapour and steam condensate from a first well to surface during a start-up phase, and the second flow line for operating the steam separator, the steam separator configured for separating the steam vapour from the steam condensate; a condensate separator coupled to the steam separator for receiving the steam condensate separated from the start-up fluids, the condensate separator configured for separating steam condensate from non-condensable gas, and for transporting start-up vapours containing the non-condensable gas to the processing facility; a cooler coupled to the steam separator and the condensate separator for receiving and cooling the steam vapour separated from the start-up fluids to generate additional steam condensate, and providing the additional steam condensate to the condensate separator; and at least one pump for pumping the start-up liquids to the processing facility.

[0014] In an implementation, the first well can be used in a production phase as a production well to receive an emulsion from the reservoir. The operating facilities can be configured to implement the start-up phase by providing steam to at least one of an injection

well and a production well, and the steam can be provided to both the injection well and the production well. The operating facilities can be configured to circulate the steam at both the injection well and the production well during the start-up phase.

[0015] In an implementation, a steam letdown valve can be used to reduce steam pressure to one or more wells at the well pad site during the start-up phase operated by the start-up operations equipment. The start-up liquids can be pumped to the processing facility via the third flow line, and the start-up vapours can be transported to the processing facility via the fourth flow line.

[0016] In an implementation, the module can further comprise a local motor control centre (MCC) for providing power and control operations to the module, the local MCC being connected to a site MCC used by the operating facilities. The local MCC can be connected to instrument air and an electrical power line provided by the site MCC.

[0017] In an implementation, the cooler can be supported atop the transportable frame and is installed thereon subsequent to the frame being transported to the well pad site. The steam separator can be temporarily coupled to the second flow line via a flexible connection to provide fuel for operating the steam separator. The steam separator can be temporarily coupled to the fourth flow line for receiving the start-up fluids from a first well during the start-up phase, via a flexible connection.

[0018] In an implementation, instrument air can be connected to the steam letdown valve for controlling operation of the steam letdown valve. The steam let down valve can be temporarily installed in a portion of the first flow line. The first flow line can be part of an expansion loop having a central length to detachably receive the steam letdown valve during the start-up phase and a pipe length during a production phase.

[0019] In an implementation, at least one component of the start-up operating equipment can be supported above at least one other component of the start-up operating equipment. The transportable frame can be sized similar to an Alberta sized module to enable roadway transportation thereof.

[0020] In an implementation, the operating facilities comprise an inlet module coupled to the module used during the start-up phase, and at least one well pair module coupled to the inlet module for interfacing with the one or more wells, the inlet module being configured to interface with the start-up module to provide the fuel gas and the start-up fluids and to receive the start-

up liquids and start-up vapours, the at least one well pair module being configured to operate using steam output from the steam let down valve and to transport start-up fluids to the inlet module during the start-up phase.

[0021] In another aspect, there is provided a method for implementing a start-up phase in a steam assisted gravity drainage (SAGD) process, the method comprising: locating a module comprising a transportable frame adjacent to at least one component of operating facilities at a well pad site; connecting the module to a steam let down valve interposed in the steam line for reducing steam pressure during the start-up phase; configuring the one or more wells to circulate steam for implementing the start-up phase; connecting the module to the operating facilities to receive start-up fluids from the one or more wells, the start-up fluids comprising steam vapour and steam condensate from a first well to surface; configuring a steam separator in the module to separate start-up fluids into the steam vapour and the steam condensate; initiating the start-up phase using steam processed by the steam letdown valve; receiving start-up fluids from the operating facilities; and operating start-up operations equipment supported by the transportable frame, to separate the start-up fluids, pump the start-up liquids to a processing facility, and transport start-up vapours containing non-condensable gas to the processing facility.

[0022] In an implementation, the method can further comprise decoupling the transportable frame from the operating facilities after the start-up phase.

[0023] In an implementation, the operating facilities at the well pad site can comprise at least a first flow line for providing steam to one or more wells, a second flow line for providing fuel gas to one or more wells, a third flow line for transporting production fluids to a processing facility, and a fourth flow line for transporting production gas to the processing facility. The start-up liquids can be pumped to the processing facility via the third flow line, and the start-up vapours are transported to the processing facility via the fourth flow line.

[0024] In an implementation, the method can further comprise connecting a local motor control centre (MCC) to a site MCC used by the operating facilities, for providing power and control operations to the module. The local MCC can be connected to instrument air and an electrical power line provided by the site MCC.

[0025] In an implementation, the start-up operations equipment can comprise a cooler for receiving and cooling the steam vapour separated from the start-up fluids to generate additional

steam condensate, and the method can further comprise supporting a cooler atop the transportable frame subsequent to the frame being transported to the well pad site.

[0026] In an implementation the method can further comprise temporarily coupling a steam separator to the second flow line via a flexible connection.

[0027] In an implementation, the method can further comprise temporarily connecting a steam separator to the fourth flow line for receiving the start-up fluids during the start-up phase, via a flexible connection.

[0028] In an implementation, instrument air can be connected to the steam letdown valve for controlling operation of the steam letdown valve. The steam let down valve can be temporarily installed in a portion of the first flow line. The portion of the first flow line can be part of an expansion loop having a central length to detachably receive the steam letdown valve during the start-up phase and a pipe length during a production phase.

[0029] In an implementation, at least one component of the start-up operating equipment can be supported above at least one other component of the start-up operating equipment. The transportable frame can be sized similar to an Alberta sized module to enable roadway transportation thereof.

[0030] In an implementation, the operating facilities can comprise an inlet module coupled to the module used during the start-up phase, and at least one well pair module coupled to the inlet module for interfacing with the one or more wells, the inlet module being configured to interface with the start-up module to provide the fuel gas and the start-up fluids and to receive the start-up liquids and start-up vapours, the at least one well pair module being configured to operate using steam output from the steam let down valve and to transport start-up fluids to the inlet module during the start-up phase.

[0031] In an implementation , the first flow line can correspond to a steam line, the second flow line can correspond to a fuel gas line, the third flow line can correspond to an emulsion line, and the fourth flow line can correspond to a production gas line.

[0032] In an implementation, the first well can be used in a production phase as a production well to receive an emulsion from the reservoir. The operating facilities can be configured to implement the start-up phase by providing steam to at least one of an injection well and a production well. The steam can be provided to both the injection well and the

production well. The operating facilities can be configured to circulate the steam at both the injection well and the production well during the start-up phase.

[0033] Implementations described herein may provide one or more of the following advantages, namely reducing at least some of the installation steps and labour required on-site, and providing an ability for removal and reuse of the start-up module subsequent to the start-up phase.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] Embodiments will now be described by way of example only with reference to the appended drawings wherein:

[0035] FIG. 1 is an isometric view of a modular well pad system for extracting bitumen from a reserve;

[0036] FIG. 2 is a schematic block diagram of a modular well pad system for extracting bitumen from a reserve with a start-up module used during a start-up phase;

[0037] FIG. 3 is a cross-sectional schematic diagram illustrating steam circulation during a start-up phase implemented by a well pair module;

[0038] FIG. 4 is a schematic block diagram of a modular well pad system for extracting bitumen from a reserve subsequent to use of a start-up module for a start-up phase in one configuration;

[0039] FIG. 5 is a schematic block diagram of a modular well pad system for extracting bitumen from a reserve subsequent to use of a start-up module for a start-up phase in another configuration;

[0040] FIG. 6 is a schematic block diagram of a modular well pad system for extracting bitumen from a reserve subsequent to use of a start-up module for a start-up phase in yet another configuration;

[0041] FIG. 7 is a schematic block diagram of a modular well pad system for extracting bitumen from a reserve subsequent to use of a start-up module for a start-up phase in yet another configuration;

[0042] FIG. 8 is an isometric view of an inlet module;

[0043] FIG. 9 is a schematic plan view of an inlet module during a start-up phase;

- [0044]** FIG. 10 is a schematic plan view of an inlet module during a production phase;
- [0045]** FIG. 11 is a schematic pipe diagram for an inlet module;
- [0046]** FIG. 12 is a schematic pipe diagram illustrating emulsion production and emulsion test streams;
- [0047]** FIG. 13 is a schematic diagram illustrating a pipe cross over configuration for an oppositely oriented inlet module;
- [0048]** FIG. 14 is an isometric view of a start-up module;
- [0049]** FIG. 15 is a schematic plan view of a start-up module coupled to an inlet module;
- [0050]** FIG. 16 is a schematic pipe diagram of a start-up module coupled to an inlet module;
- [0051]** FIG. 17 is an elevation view showing the operating equipment contained by the start-up module;
- [0052]** FIG. 18 is an isometric view of a well pair module;
- [0053]** FIG. 19 is a schematic plan view of a well pair module;
- [0054]** FIG. 20A is a schematic elevation view of a well pair module during a production phase;
- [0055]** FIG. 20B is a schematic elevation view of a well pair module during a start-up phase;
- [0056]** FIG. 21A is a schematic pipe diagram of a well pair module in a production configuration; and
- [0057]** FIG. 21B is a schematic pipe diagram of a well pair module in a start-up configuration.

DETAILED DESCRIPTION

[0058] The modularity of the equipment used at a well pad site can be increased by providing an inlet module interposed between the gathering lines, connecting the well pad site to the CPF and one or more well pair modules configured to operate one or more well pairs; and a start-up module that can interface with the inlet module during a start-up phase to operate the

well pair modules to achieve fluid communication in the interwell region between the injection and production wells that make up the well pairs.

[0059] The start-up module used during the start-up phase includes a transportable frame that can be detachably coupled to operating facilities at a well pad site. The transportable frame includes and supports start-up operations equipment for implementing the start-up phase. The start-up operations equipment that are supported by a transportable frame are able to temporarily configure the operating facilities to implement the start-up phase and be removable from the well pad site thereafter.

[0060] The operating facilities at the well pad site can comprise at least a steam line for providing steam to one or more wells, a fuel gas line for providing fuel gas to one or more wells, an emulsion line for transporting production fluids to a processing facility (e.g., a central processing facility), and a production gas line for transporting production gas to the processing facility.

[0061] In an implementation of the start-up module, the start-up operations equipment includes a steam separator detachably coupled to the operating facilities at the well pad site to transport start-up fluids comprising steam vapour and steam condensate generated during a start-up phase. It has been found that a production gas line used to gather production gases from a production well during a production phase can be repurposed to collect such start-up fluids during the start-up phase. The start-up module can also be detachably coupled to the fuel gas line for operating the steam separator. The steam separator can be configured for separating the steam vapour from the steam condensate. The start-up operations equipment can also include a condensate separator coupled to the steam separator for receiving the steam condensate separated from the start-up fluids, the condensate separator being configured for separating steam condensate from non-condensable gas, and for transporting start-up vapours containing the non-condensable gas to the processing facility. The start-up operations equipment can also include a cooler coupled to the steam separator and the condensate separator for receiving and cooling the steam vapour separated from the start-up fluids to generate additional steam condensate, and for providing the additional steam condensate to the condensate separator. The start-up operations equipment can also include at least one pump for pumping the start-up liquids to the processing facility.

[0062] In an implementation of the start-up module, during the start-up phase, the start-up liquids are pumped to a central processing facility via the emulsion line, and the start-up vapours are transported to the central processing facility via the production gas line.

[0063] In an implementation of the start-up module, the module further includes a local motor control centre (MCC) for providing power and control operations to the module, the local MCC being connected to a site MCC used by the operating facilities.

[0064] In an implementation of the start-up module, the cooler is supported atop the transportable frame and is installed thereon subsequent to the frame being transported to the well pad site.

[0065] In an implementation of the start-up module, a steam let down valve is temporarily installed in a portion of the steam line in the inlet module. For example, the portion of the steam line can be part of an expansion loop having a central length to detachably receive the steam letdown valve during the start-up phase and a pipe spool during a production phase.

[0066] In an implementation of the start-up module, the transportable frame is sized similar to an Alberta sized module to enable roadway transportation thereof.

[0067] In an implementation of the start-up module, the operating facilities includes an inlet module coupled to the start-up module, and at least one well pair module coupled to the inlet module for interfacing with the one or more wells. The inlet module in this implementation is configured to interface with the start-up module to provide the fuel gas and the start-up fluids and to receive the start-up liquids and start-up vapours. The at least one well pair module is configured to operate using steam output from the steam let down valve and to transport start-up fluids to the inlet module during the start-up phase.

[0068] A start-up phase in a SAGD process can be implemented by locating a module having a transportable frame adjacent to at least one component of operating facilities at a well pad site. The operating facilities at the well pad site include a steam line for providing steam to one or more wells, a fuel gas line for providing fuel gas to one or more wells, an emulsion line for transporting production fluids to a processing facility, and a production gas line for transporting production gas to the processing facility. The process in this implementation also includes connecting the module to a steam let down valve interposed in the steam line for reducing steam pressure for the steam being used during the start-up phase. The process also includes configuring the one or more wells to circulate or bullhead steam during the start-up

phase. The module in this implementation is connected to the operating facilities to receive start-up fluids generated by the one or more wells during start-up (*i.e.*, steam vapour and steam condensate), by repurposing the production gas line. The fuel gas line can be connected to a steam separator in the module to provide fuel to the steam separator to separate such start-up fluids into the steam vapour and the steam condensate. The start-up phase can be initiated using steam processed by the steam letdown valve, receiving start-up fluids from the operating facilities, and operating start-up operations equipment to separate the start-up fluids, pump the start-up liquids to the processing facility, and transport start-up vapours containing non-condensable gas to the processing facility.

[0069] Turning now to the figures, FIGS. 1 and 2 illustrate a modular well pad system 10 (“modular system 10” hereinafter) installed near a series of wells at a well pad site 12. The modular system 10 is used for in-situ bitumen recovery, *e.g.*, using SAGD as shown therein. The modular system 10 includes an inlet module 14 that is configured to interface with a series of lines running to/from a CPF – not shown, and collectively identified in the figures as the “gathering lines” 16 (see FIG. 2).

[0070] The modular system 10 also includes a start-up module 18, which is temporarily coupled to the inlet module 14 to implement a start-up process. The start-up module 18 can be decoupled from the inlet module 14 and removed from the well pad site 12, *e.g.*, for use at another site. As will be described in greater detail below, by incorporating the various start-up equipment in a single transportable module, the start-up module 18 reduces the amount of time and cost associated with setting up the well pad site 12 and can also be conveniently moved and reused at other similarly configured well pad sites 12 by integrating the start-up module 18 with a similar inlet module 14 at the other well pad sites 12.

[0071] The inlet module 14 is utilized to change over from pipeline regulations, registration requirements, codes, etc. governing the gathering lines 16; to facilities regulations governing the plumbed piping on the well pad site 12. The inlet module 14 is also used to enable the start-up module 18 to interoperate with a series of one or more well pair modules 20 during a start-up phase. Both during the start-up phase, and after the start-up module 18 is removed for a production phase, the inlet module 14 interoperates with the one or more well pad modules 20 during the production phase. Additionally, the inlet module 14 returns an emulsion stream and a production gas stream to the gathering lines 16 to be transported back to the CPF in this

example implementation, and to perform multi-phase testing of emulsion test streams, during the production phase.

[0072] Each well pair module 20 is identically or substantially identically constructed to be capable of interfacing with either the inlet module 14 or another well pair module 20 at one end, and at an opposite end to interface with yet another well pair module 20 or is end-capped. The well pair modules 20 each connect to a series of injection wells 22 and a series of production wells 24 for performing SAGD operations. In the example shown in FIG. 2, each well pair module 20 is connected to three oppositely located pairs of wells 22, 24, however, it can be appreciated that a well pair module 20 can be sized and configured to connect to more or fewer well pairs 22, 24. For example, in one implementation, a pair of 2-well modules (not shown) can be used to create a combination of 3- and 2-well modules that, when combined, can service a set of ten well pairs 22, 24 at a particular well pad site 12.

[0073] The modular system 10 also includes a motor control centre (MCC) 26 that is connected to the inlet module 14 and the well pair modules 20 after installation, and is temporarily connected to the start-up module 18. The MCC 26 acts as a command and control center for the entire well pad site 13 and particularly provides a main power source that is distributed to the other modules by receiving a main power source and performing voltage conversion suitable for use by the MCC 26 itself, and the other modules 14, 18, 20. The power is used to provide lighting, HVAC and other amenities. The MCC 26 can also include at least one air compressor for generating instrument air that is used by the MCC 26 itself and the other modules 14, 18, 20. The MCC 26 can also be connected via communication lines to the other modules 14, 18, 20 in order to collect end-device information which can be sent back to the CPF, *e.g.*, for reporting, monitoring, etc.

[0074] The start-up module 18 is coupled to the inlet module 14 via certain temporary connections, such that various operations are controlled by or through the start-up module 18 during the start-up phase, as shown in greater detail below. In this way, the start-up module 18 can temporally interface with the CPF and the well pair modules 20 via the inlet module 14 to implement the start-up phase. In particular, the start-up module 18 is operable in connection with the inlet module 14 to reduce the steam pressure originating from the gathering lines 16 to an appropriate pressure suitable for circulating steam in the well pairs 22, 24 to establish fluid communication in the interwell region between the injection and production wells 22, 24. The start-up fluids generated at the wells 22, 24 during the start-up phase can also be diverted to the

start-up module 18 to process these fluids for transportation back to the CPF via the gathering lines 16.

[0075] To allow for different lengths of time for start-up to be achieved at different well pairs 22, 24, the start-up module 18 and well pair modules 20 are also configured to process fluids during simultaneous production and start-up from different wells at the same well pad site 12. That is, produced bitumen from at least one production well 24 can be transported to the CPF at the same time as fluids and vapours generated while circulating steam at a well pair 22, 24 currently in the start-up phase. As such, wells 22, 24 that are ready to commence SAGD can be configured to do so without having to be delayed while other wells 22, 24 at the well pad site 12 are achieving start-up.

[0076] FIG. 3 illustrates operation of a well pair module 20 in a steam circulation configuration during a start-up phase. In this implementation, steam is injected, using a steam branch line 130 from the well pair module 20, into a long tubing 21 that extends to the toe of the injection well 22. In this implementation, steam is also injected into a tubing 21 that extends to the toe of the production well 24. The steam is used to warm the interwell region 25 between the injection well 22 and the production well 24 to achieve fluid communication between the two wells 22, 24. The steam circulates back to the well pair module 20 via an annulus 23 between the tubing 21 and a casing (or other tubing such as short tubing - not shown) in the respective well 22, 24. This circulated steam typically includes both vapours and liquids, referred to herein as start-up fluids. For the injection well 22, a temporary line 130' is installed, which connects the annulus 23 to a production gas line to gather the start-up fluids, wherein the annulus 23 would normally be connected to a steam header during a production phase. For the production well 24, a temporary line 134' is installed, which connects the steam header in the well pair module 20 to the tubing 21 to enable the production well 24 to be steamed. Normally, the tubing 21 in the production well 24 can be connected to an emulsion group branch line 134 (see FIG. 20A) for producing an emulsion to surface. During steam circulation, a reconfigured production gas branch line 136' can be used to return start-up fluids from the annulus 23 in the production well 24, to the well pair module 20.

[0077] It can be appreciated that while the configuration shown in FIG. 3 includes steaming both the injection well 22 and the production well 24, other start-up configurations can be used. For example, only the injection well 22 may be steamed, or likewise only the production well 24 may be steamed. Steam bullheading can also be used, by blocking lines 130' and 136' and

injecting steam into the reservoir via the tubing 21 in one or both of the injection well 22 and the production well 24. Steam circulation can also be applied, followed by bullheading, or vice versa.

[0078] FIG. 4 illustrates, using dashed lines, the configuration of the modular system 10 subsequent to the start-up phase and after removing the start-up module 18 from the modular system 10. By removing the start-up module 18 and returning the inlet module 14 and well pair modules 20 to their production configurations, the production phase can begin without requiring significant restructuring and by allowing the equipment used in the start-up phase to be removed from the well pad site 12 and reused elsewhere.

[0079] FIGS. 4 through 7 illustrate how the inlet module 14 can be adapted to accommodate four different configurations of the modular system 10 to account for different well pair positions and to enable the inlet module 14 to tie into the gathering lines 16 from either side thereof. In FIG. 4, a first configuration is shown (configuration A), referred to herein as a right-handed configuration, with the injection wells 22 located on the same side as the MCC 26 and the production wells 24 located on the opposite side.

[0080] In FIG. 5, another right-handed configuration is shown (configuration B), with the production wells 24 being located on the same side as the MCC 26 and the injection wells 22 being located on the opposite side. As will be described in greater detail below, the inlet module 14 can be reconfigured for oppositely oriented well pair modules 20 (as shown using upside down text in FIG. 4) without having to reconfigure the well pair modules 20. This can be done in various ways, for example, by selecting from different spools to be coupled to the ends of the inlet module 14 to account for different ordering of the flow lines. In this way, the number of variations in the modules can be minimized by making piping cross-over changes in only the inlet module 14. The well pair modules 20 can therefore be built to a single specification and the inlet module 14 adapted to accommodate the particular well pad layout being used prior to shipping the modules 14, 20 to the well pad site 12.

[0081] FIG. 6 illustrates a left-handed configuration (configuration C) in which the inlet module 14 is configured to branch off from the gathering lines 16 in the opposite direction while interfacing with the well pair modules 20 without having to reconfigure the well pair modules 20. Similar to FIG. 4, the well pair modules 20 in configuration C are connected to injection wells 22 located on the same side as the MCC 26 with the production wells 24 on the opposite side.

[0082] FIG. 7 illustrates another left-handed configuration (configuration D) in which the inlet module 14 is configured interface with the well pair modules 20 when the injection and production wells 22, 24 are oppositely located, similar to configuration B.

[0083] FIG. 8 illustrates an isometric view of the inlet module 14, with portions partially cut away or removed for visibility within the structure. As can be seen, flow lines to/from the gathering line 16 enter the inlet module 14 at grade, at which point regulatory conversion takes place by terminating the gathering lines branching from the gathering lines 16 at flanges that are coupled to flanges (flanges not shown in FIG. 8) which begin the piping that is compliant with facilities code. A steam line 30 and a fuel gas line 32 connect to the inlet module 14 from the CPF. An emulsion group line 34 and an production gas line 36 (also known as annulus gas or field gas) extending from the inlet module 14 connect to the gathering lines 16 to carry emulsion and production gas streams respectively back to the CPF. The steam line 30, fuel gas line 32, emulsion group line 34, and production gas line 36 fluidly connect through the inlet module 14 towards the gathering lines 16 from the adjacent well pair module 20. The inlet module 14 is also connected to an emulsion test line 35 that carries an emulsion stream from a particular production well 24 for testing purposes as will be explained below. The emulsion test stream is fluidly connected into the emulsion group line 34 via the emulsion test line 35 to add the production stream being tested to the emulsion group line 34 for transportation to the CPF.

[0084] The steam line 30 is diverted towards an upper portion of the inlet module 14 and carried along the length of the inlet module 14 to interface with an adjacent well pair module 20 at an upper portion thereof. The steam line 30 includes an expansion loop 40 to accommodate thermal expansion of the steam line 30. A portion of the steam line 30, *e.g.*, a portion of the expansion loop 40, is adapted to include either a steam letdown valve 80 (see also FIG. 9) or a production pipe length 42 (see also FIG. 10) that enables steam letdown during the start-up phase and after start-up, the steam in the steam line 30 to be provided to the well pair modules 20.

[0085] The inlet module 14 also includes a central operating level 41 wherein fluids from the fuel gas line 32, emulsion group line 34, and production gas line 36 are carried into; for performing operating functions such as pressure adjustment, valve control, etc. The other flow lines connected to the inlet module 14 at the opposite side (*i.e.*, the fuel gas line 32, the emulsion group line 34, the emulsion test line 35, and the production gas line 36) are provided at grade to interface with the adjacent well pair module 20.

[0086] As shown in dashed lines in FIG. 8, one or more interchangeable spools 43a, 43b can be used to implement a cross-over configuration to accommodate the relative positioning of the well pair module 20 in the field. For example to convert the inlet module 14 in configuration A to configuration B, the spools 43b at the well pair module 20 end of the inlet module 14 can be interchanged to cross-over the order of the flow lines to account for the physical rotation of the well pair modules 20 relative to the inlet module 14. Similarly, to convert the inlet module 14 from configuration A to configuration C, the spools 43a at the gathering line end of the inlet module 14 can be interchanged to cross-over the order of the piping that will interface with the gathering lines branching from the gathering lines 16. It can be appreciated that interchangeable spools (not shown in FIG. 7) can also be used to cross over the other flow lines 32, 34, 35, and 36 and the dashed lines associated with spools 43a and 43b in FIG. 7 are provided to illustrate only an exemplary cross-over of the steam line 30.

[0087] The inlet module 14 is adapted to be used in a start-up configuration in order to divert particular flow lines to/from the start-up module 18, and to be used in a production configuration. FIG. 9 schematically illustrates the flow inputs and outputs to/from the inlet module 14 in the start-up configuration. The steam letdown valve 80, which is operationally part of the start-up module 18, is installed within the main steam line 30 associated with the inlet module 14 (e.g. along a portion of the expansion loop 40) to reduce the steam pressure to a level suitable for start-up.

[0088] The fuel gas line 32 is branched at the operating level 41 (see FIG. 8) of the inlet module 14 to connect with the start-up module 18 via a fuel gas branch line 48 for use in a start-up separation process, to be described in greater detail below. The start-up separation process outputs a stream of start-up vapours 46 that is temporarily tied into the production gas line 36 in the inlet module 14, to be transported to the CPF. A stream of start-up liquids 44 is also generated by the separation process, which is temporarily tied into the emulsion group line 34 in the inlet module 14, to be transported to the CPF. The start-up liquids 44 and start-up vapours 46 are separated from a start-up fluid stream 52 that is transported from the well pair module(s) 20 via the interconnected production gas line 36.

[0089] FIG. 10 schematically illustrates the inlet module 14 in a production configuration. In the production configuration, the steam letdown valve 80 is removed and replaced with the production pipe 42 at the central length in the expansion loop 40, and the fuel gas branch line 48 is shut off. The emulsion group line 34 used to transport production fluids to the CPF,

gathers the emulsion streams from the well pair module(s) 20 and gathers an emulsion testing stream via the emulsion testing line 35 as illustrated in FIG. 11. The production gas line 36 from the adjacent well pair module 20 is used to gather production gas streams from the well pair modules 20 and transports the production gas to the CPF via the gathering line 16.

[0090] FIG. 11 illustrates the connectivity of the piping connecting to or passing through the inlet module 14, with dashed lines representing temporary connections used during the start-up phase when the start-up module 18 is coupled to the inlet module 14. It can be appreciated that various lines, such as instrument air, would also be included but are not shown to improve readability of this and the other piping schematics shown herein. The steam line 30 includes the expansion loop 40, which both accommodates thermal expansion of the steam line 30 and aligns the steam line 30 with a mating flange on the adjacent well pair module 20. During the start-up phase, the steam letdown valve 80 is installed in the steam line 30. The fuel gas line 32 connections are also shown in greater detail in FIG. 11. The fuel gas line 32 is fed into a fuel gas heater (FGH) 64 via a heater inlet line 60 to heat the raw fuel gas suitable for use at the wells 22, 24. As is known in the art, gas pressure letdowns result in thermal sub-cooling to very low temperatures (per the Joules Thompson Effect). The FGH 64 warms the lower pressure fuel gas to the design temperature of the inlet module's fuel gas distribution headers, which are not designed for low temperature service (e.g., -29 degrees Celsius or lower). The heated fuel gas is tied back into the fuel gas line 30 via a heater outlet line 62.

[0091] As also illustrated in FIG. 11, in the start-up phase, a valve 66 is used to branch the heated fuel gas to a start-up separator 87 (see also FIG. 16). The start-up separator 87 is operated along with other start-up operating equipment 82 (see also FIG. 15) as discussed below, to separate and process the start-up fluids for transportation to the CPF via the gathering lines 16. The start-up liquids 44 and start-up vapours 46 thus separated are tied into the emulsion group line 34 and production gas line 36 respectively. During the production phase, the valve 66 is closed as indicated above.

[0092] The emulsion group line 34 is tied into the gathering line 16 to transport produced fluids to the CPF. During the start-up phase, the emulsion group line 34 can still be used to gather produced SAGD fluids from producing wells 24, even when at least one other well pair 22, 24 is still achieving start-up. The emulsion test line 35 can similarly be used for testing producing wells 24 while at least one well pair 22, 24 is still achieving start-up. That is, the inlet

module 14 and well pair modules 20 are configured to enable the start-up phase to be implemented in part along with the production phase being implemented in part.

[0093] During the production phase, the emulsion group line 34 gathers the emulsion streams from the well pair modules 20. Depending on the number of wells at the site 12, a particular one of the wells can be tested by routing the production stream to the inlet module 14 via the corresponding emulsion test line 35. In the modular system 10, a multi-phase flow meter (MPF) 74 is used to test the emulsion stream of a particular well without requiring a test separator and the associated equipment required with a test separator such as a flare stack used to burn non-condensable gas. The emulsion test line 35 diverts the test stream to the MPF 74 via a flow meter inlet line 72. The tested fluid is tied into the emulsion group line 34 from a flow meter outlet line 70.

[0094] The production gas line 36 is used to carry the start-up fluids during the start-up phase, and by opening the valve 68, the start-up fluids are diverted to the start-up separator 87 in the start-up module 18 to feed into the operating equipment 82 in order to separate the start-up liquids 44 and the start-up vapours 46.

[0095] FIG. 12 illustrates the emulsion group stream and the emulsion test stream. During the production phase, the emulsion group stream gathers produced fluids via the emulsion group line 34 and the entire production stream is sent to the CPF via the gathering line 16 rather than being separated to avoid the need for a group separator. Avoiding the group separator can reduce cost and space constraints. The entire emulsion test stream is tested using the MPF 74, thus eliminating the need for a test separator as discussed above, which eliminates the need for a PSV and flare stack at the well pad site 12.

[0096] Discussed above and shown in FIGS. 4 to 7 are various interchangeable configurations for the inlet module 14. By enabling cross-over connections as illustrated in FIG. 13, both left- and right-handed configurations can be implemented, before transporting the inlet module 14 to the well pad site 12. The cross-over spools used to cross-over the connections can be implemented in any suitable configuration given the space constraints of the inlet module 14. For example, bends in the spools 43a, 43b can be used to carry a line from one side of the inlet module 14 to the other side of the inlet module 14.

[0097] FIG. 14 is an isometric view of the start-up module 18. The start-up module 18 includes a transportable frame 75 that contains the operating equipment 82 used during the

start-up phase within a multi-level, compact module. While not shown in FIG. 14, the frame 75 can include a stairway to enable personnel to move between the levels for operating the start-up operating equipment 82. The transportable frame is preferably sized to allow for transportation within the Canadian province of Alberta. The operating equipment 82 includes a start-up cooler 84, startup separator 87, start-up condensate separator 89, and start-up pumps 95 (see also FIG. 16 described below). Moreover, the start-up module 18 can optionally include a local MCC 85 to power and control the operating equipment 82 without having to connect into the main MCC 26 on-site. Compared to previous well pad configurations (in which similar functionality was provided using multiple individual stations that were built on-site), the start-up module 18 reduces the amount of on-site assembly and can be removed and reused subsequent to the start-up phase. The start-up module 18 is configured to interface with the inlet module 14 to receive and return fluids diverted to/from the start-up module 18 using temporary connections, during which the other modules in the modular system 10 are adapted to be used during the start-up phase.

[0098] FIG. 15 provides a schematic view showing connections between the start-up module 18 and the inlet module 14 during the start-up phase. During the start-up phase, the steam letdown valve 80 is installed in the steam line 30 of the inlet module 14 in order to reduce the steam pressure. While physically included in the inlet module 14, the steam letdown valve 80 is considered part an operational component of the start-up module 18 since it is used while the start-up module 18 is being used in the system 10. As noted above, a spool of piping can be removed from the steam line 30 to accommodate installation of the steam letdown valve 80. Instrument air that is present in the inlet module 14 can be connected to the steam letdown valve 80 to actuate and control the valve mechanism itself.

[0099] The fuel gas branch line 48 diverts the heated fuel gas to the start-up operating equipment 82 for use in operating the start-up module 18. Similarly, a start-up fluid stream 52 generated by the start-up steam circulation being implemented at the wells is fed into the operating equipment 82 to separate the vapours and fluids and return start-up liquids 44 and start-up vapours 46 to the CPF. The local MCC 85 provides the necessary power and control sources to operate the start-up module 18 within minimal set-up requirements on-site, and can itself be powered by the main MCC 26.

[00100] FIG. 16 illustrates further detail of the connectivity between the start-up operating equipment 82. The start-up operating equipment 82 works in conjunction with the steam

letdown valve 80 for reducing the steam pressure during the start-up phase and processing received start-up fluids. The start-up operating equipment 82 contained in/on the start-up module frame 75 includes the start-up separator 87 for separating the start-up fluids into steam vapour and steam liquid (*i.e.* hot water), the start-up condensate separator 89 for separating non-condensable gases from the condensed liquid, the start-up cooler 84 for condensing steam in the start-up fluids, and start pumps 95 for pumping the condensed start-up liquids to the CPF via the gathering lines 16. The fuel gas branch line 48 can be connected to the start-up separator 87 via a flexible joint 86 to accommodate flexion, vibration, and expansion of the heated fuel gas. The start-up fluid stream line 52 can also be connected to the start-up separator 87 using a flexible joint 88 to accommodate expansion, vibration, and flexion during operation, and to assist with alignment and assembly.

[00101] The start-up separator 87 and start-up condensate separator 89 are used to separate the start-up vapours 46 from the start-up liquids 44. The start-up fluids carried by the start-up fluids line 52 include both steam vapour and steam condensate that are produced out of the wells that are undergoing the start-up phase. The start-up module 18 is therefore configured to avoid transporting steam vapour to the CPF to avoid stresses on the piping that can be caused by fluid “knocking” when steam vapours are present along with condensate, which can be explosively propelled by the steam vapours. The start-up separator 87 performs the initial separation of the start-up fluids, by separating the steam vapour from the steam liquid. The steam vapours are fed via a cooler inlet line 90 to the start-up cooler 84 to condense the vapours. The condensed vapours are then returned via a cooler outlet line 92 to the start-up condensate separator 89. The liquid from the start-up separator 87 is fed via a condensate inlet line 94 to the start-up condensate separator 89. The start-up condensate separator 89 separates the condensed liquids from any non-condensable gases, for example, nitrogen. The non-condensable gases thus separated are referred to as the start-up vapours 46, which are transported to the CPF via the production gas line 36.

[00102] The start-up condensate separator 89 feeds the condensed liquid to the start-up pumps 95 via a pump inlet line 96. The start-up pumps 95 are operated to pump the condensed liquids, referred to herein as the start-up liquids 44, to the CPF via the emulsion group line 34. The start-up liquids 44 and start-up vapours 46 separated from the start-up fluids by the start-up module 18 are returned to the inlet module 14 to be tied into the emulsion group line 34 and production gas line 36 for transport to the CPF. Also shown in FIG. 15 is the steam letdown

valve 80 which is controlled by a control line 77 from a proportional integral derivative (PID) controller 78 (or other suitable controller). The PID controller 78 receives a pressure signal 76 that is monitored to control operation of the steam letdown valve 80.

[00103] FIG. 17 illustrates an elevation view of the start-up module 18. From this view it can be seen that the operating equipment 80 is supported within or on the transportable frame 75 to achieve a compact configuration that allows the start-up module 18 to be temporarily coupled to the inlet module 14 and removed for transportation to another well pad site 12 after the start-up phase is complete. This avoids having decommissioned equipment on site and creates more space around the inlet module 14 as well as easing access to the well pair modules 20. In the configuration shown in FIG. 17, the start-up separator 87 is supported above the start-up condensate separator 89 and towards a front end of the frame 75 to couple with the fuel gas branch line 48 and the start-up fluid line 52. The start-up cooler 84 is located above and to the rear of the start-up separator 87 by a mid-portion of the frame 75. The start-up cooler 84 can be transported separately and installed on the frame 75 at the well pad site 12 if height restrictions are present, for example if the start-up cooler 84, when installed is too high for transportation restrictions along the transportation route. The frame 75, the start-up cooler 84, and the steam letdown valve 80 can therefore be shipped to the well pad site 12 to collectively be installed temporarily for operating the start-up module 18. The start-up cooler 84 would be mounted atop the frame 75 as shown in FIG. 17, and the steam letdown valve 80 installed in the steam line 30 as described above.

[00104] The start-up cooler 84 and the start-up separator 87 feed condensed liquid and vapours to the start-up condensate separator 89 via the lines 92 and 94 respectively. The start-up condensate separator 89 feeds the condensed liquids to the start-up pumps 95 located behind the start-up condensate separator and beneath the start-up cooler 84 to pump the condensed liquids via the start-up liquid line 44 to the CPF via the emulsion line tie in that is located in inlet module 14. The start-up condensate separator 89 also feeds the non-condensable vapours via the start-up vapour line 46 to the inlet module 14 to be transported to the CPF.

[00105] The local MCC 85 can be supported within a rearmost portion of the frame 75 and can be connected to the operating equipment 82 to supply power and control.

[00106] Turning now to FIG. 18, an isometric view of the well pair module 20 is shown. The well pair module 20 can be an enclosed module that includes an upper portion 106 carrying the

steam line 30, a middle operating level 112, and a lower portion 108. The lower portion 108 carries the fuel gas line 32, the emulsion group line 34, the emulsion test line 35, and the production gas line 36. The steam line 30 is carried overhead, and the other flow lines carried on the lower portion 108 in order to interface with the inlet module 14. Three sets of production lines 102 are visible in FIG. 18, which connect the operating equipment found at the operating level 112 to the production wells 24. The equipment found at the operating level 112 can include, without limitation, operator controls for switching valves to switch between emulsion test and emulsion gathering streams; monitoring, measuring, and controlling steam injectors; distributing fuel gas; electric heat tracing; input/output panels; and any other equipment that operates the well pair module 20 and which is not located in the wells 22, 24 themselves. For clarity, the operating equipment in the operating level 112 has been omitted from FIG. 18. Connections between the steam line 30, the operating level 112, and the lower portion 108 coupled to the wells 22, 24 is illustrated in FIGS. 20A and 20B.

[00107] Referring to FIGS. 18 and 19, during the production phase, the steam and fuel gas are directed down and outwardly towards the injection well 22. Fuel gas can also be directed down and outwardly towards the production wells 24. The fuel gas can be used as a blanket gas in the injection wells 22 during production to inhibit heat loss along the tubing(s) used to inject steam into the injections wells 22. The fuel gas can also be used in either or both the injection and production wells 22, 24 to provide a forced gas column to the reservoir, enabling reservoir pressure to be measured. Emulsion streams and production gas streams are fed back to the operating level 112, from the production wells 24, in order to be transported back along the well pair modules 20 to the inlet module 14.

[00108] During a start-up phase, the well pair module 20 is configured in the operating level, to circulate or bullhead steam in one or more of the wells of the well pairs 22, 24. It can be appreciated that if bullheading is successful, without steam circulation being required, the start-up module 18 can be removed from the site earlier, *e.g.*, after initial drilling and other fluids are cleaned out using the produced gas line as herein described. When steam circulation is used during the start-up phase, the well pair module can be configured to return start-up fluids along the production gas line 36 to the start-up fluids line 52. As discussed above, the well pair module 20 can be operated to selectively run both production and start-up phases at the same time. This can be done by detecting when a bitumen-containing emulsion begins to show in a particular injection or production well 22, 24 that has been circulating in the start-up phase (*i.e.*

a material amount of bitumen is found in the water condensate that returns from the production well 24). At that time, the well pair 22, 24 is isolated and the temporary connections used for the start-up phase removed at the operating level 112 and these wells recommissioned for the production phase. This is particularly advantageous since well pairs 22, 24 can require different amounts of time to achieve start-up and the flexibility of the well pair modules 20 enables those well pairs 22, 24 that do achieve start-up to begin producing while continuing to circulate steam at the other well pairs 22, 24 that are not yet ready for production.

[00109] It may be noted that since well pairs 22, 24 may still be in the start-up phase, the steam letdown valve 80 would remain in the steam line 30 of the inlet module 14 as herein described. It can be appreciated that the steam pressure with the steam letdown valve 80 in place would still be enough to achieve steam injection to begin the production phase in those well pairs 22, 24 that are ready to commence production before others. In this way, the added protection provided by the steam letdown valve 80 can remain in place until all well pairs 22, 24 at the well pad site 12 are ready for the production phase, and would remain installed until all of the well pairs 22, 24 at the well pad site 12 are in a production phase.

[00110] FIG. 19 schematically illustrates a plan view of the well pair module 20. FIG. 19 illustrates the flow lines terminating at each longitudinal end of the well pair module 20 and the injection piping 100 and production piping 102 extending out towards the injection wells 22 and production wells 24 respectively as is known in the art. It can also be appreciated from FIG. 19 that multiple well pair modules 20 can be linked together to service any suitable number of well pairs 22, 24 required by the well pad site 12 while enabling each well pair module 20 to tie back into the various flow lines that ultimately interface with the inlet module 14 and the start-up module 18. By providing valves and controllers in the operating level 112, the operators can configure the well pair module 20 to be operating in the start-up phase or the production phase by directing fluids towards the corresponding flow lines herein described.

[00111] FIG. 20A illustrates schematically, fluid line connections and flow directions for the well pair module 20 in a production phase configuration. The steam line 30 in this configuration is carried overhead in the upper portion 106 of the well pair module 20 and the emulsion group line 34, emulsion test line 35, fuel gas line 32 and production gas line 36 are carried along the lower portion 108 of the well pair module 20. The lines 32, 34, 35, 36 include various branch lines 114 extending up to, or down from, an operating level 112 where the aforementioned operating equipment is located for operating the well pair module 20, switching between a start-

up configuration and the production configuration shown in FIG. 20A, etc.. Similarly, the steam line 30 includes branch lines 110 extending down to the operating level 112.

[00112] In the production phase configuration shown in FIG. 20A, each production well 24 is connected to the well pair module 20 by a production fuel gas branch line 132b, to supply fuel gas to the production well 24 as described above. An emulsion group branch line 134 connects the tubing 21 of the production well 24 into the emulsion group line 34 or emulsion test line 35 during the production phase, to produce fluids collected by the production well 24. The production well 24 is also connected to a production gas branch line 136 to deliver production gases gathered during the production phase into the production gas line 36. In the production phase, the annulus 33 of the injection well 22 can be connected to the well pair module 20 by a first steam branch line 130 for injecting steam into the reservoir during a production phase. The tubing 21 of the injection well 22 can be connected to the well pair module 20 by a second steam branch line 131 for also injecting steam into the reservoir during the production phase. The injection well 22 can also be connected to the well pair module by an injection fuel gas branch line 132a, to supply fuel gas to the injection well 22 as described above. The lower portion 108 of the well pair module 20 also supports one or more cable trays 116 along the lower portion 108 to support electrical and communication cables that are used to feed the operating equipment at the operating level 112 and the wells.

[00113] FIG. 20B illustrates the well pair module 20 in a start-up configuration that at least in part uses steam circulation. It can be appreciated that, as discussed above, steam bullheading can also be implemented by blocking the return paths at the wells being steamed. In FIG. 20B, the tubing 21 of the production well 22 can be connected to the well pair module 20 via a temporary start-up steam injection line 134' that injects steam into the production well 24 during the start-up phase. This temporary start-up steam injection line 134' can be tied to the steam header 30 at the operating level 112 (see also FIG. 21B described below). During the start-up phase, a reconfigured production gas branch line 136' can be used to circulate start-up fluids into the production gas line 36 (see also FIG. 21B described below). During the start-up phase, the injection well 22 is configured to temporarily connect the annulus 23 to the production gas line 36 using a temporary steam circulation line 130'. This temporary steam circulation line 130' can be tied to the production gas line 36 at the operating level 112. It can be appreciated from FIG. 20B that the well pair module 20 can be adapted for use in both start-up and production phases with particular modifications to the flow lines.

[00114] FIGS. 21A and 21B schematically illustrate the piping connectivity within the well pair module 20 for interfacing between the injection and production piping 100, 102 and the flow lines that are connected to the inlet module 14 and start-up module 18 via one or more well pair modules 20. FIG. 21A illustrates the piping connectivity in a production configuration, and FIG. 21B illustrates the piping connectivity in a start-up configuration. Referring first to FIG. 21A, the emulsion group branch line 134 ties into the emulsion group line 34 and connects to the wellhead of the production well 24. The emulsion group branch line 134 of the production well 24 can also be tied into the emulsion test line 35 to enable the production well 24 to be placed in a test phase during operation of the well pair module 20. The production well 24 can also be connected to the fuel gas line 32 via the fuel gas branch line 132b. As discussed above, the annulus 23 of the production well 24 can be connected to the production gas line 36 using the production gas branch line 136 to transport production gases to the CPF via the inlet module 14 during the production phase. The injection well 22 shown in FIG. 21A is also connected to the fuel gas line 32 via an injection fuel gas branch line 132a, to provide blanket gases and a forced gas column if desired. The steam line 30 in this implementation can be connected to both the tubing 21 and annulus 23 of the injection well 22 during the production phase to inject steam into both the tubing 21 and the annulus 23..

[00115] FIG. 21B includes a number of dashed lines illustrating an example of an implementation that incorporates the modified flow lines 130', 134', and 136' shown in FIG. 20B. Valves connecting the emulsion group branch line 134 to the emulsion group line 34 and the emulsion test line 35 can be closed, and nozzle changes implemented at the production well 24. Such nozzle changes are illustrated in FIG. 21B by interchanging the "tubing" and "annulus" labels. A valve situated along the steam branch line 130 can also be closed. These valve closures and nozzle changes allow the annulus 23 of the production well 24 to be tied into the production gas line 36 via the reconfigured production gas branch line 136'. Similarly, the tubing 21 of the production well 24 can be tied into the steam line 30 via the second steam branch line 131 that injects steam into the tubing 21 of the injection well 22 using the temporary start-up steam injection line 134'. With the valve along the production gas branch line 136 being closed as illustrated in FIG. 21A, the annulus 23 of the injection well 22 can be tied into the production gas line 36 using the temporary steam circulation line 130' for circulating the steam during the start-up phase.

[00116] The modular system 10 can be adapted to implement the start-up phase once the inlet module 14 and well pair module(s) 20 is/are installed at the well pad site 12. The start-up module 18 is temporarily coupled to the inlet module 14 as discussed above, and the well pair modules 20 are configured at the operating level 112 to circulate steam at both the injection wells 22 and the production wells 24 and to transport start-up fluids resulting from this process to the inlet module 14 via the production gas line 36.

[00117] The inlet module 14 can be configured to divert the start-up fluids received via the production gas line 36 to the start-up fluid line 52 and into the start-up module 18. The inlet module 14 can also be configured to provide fuel gas to the start-up module 18 via the fuel gas branch line 48. Instrument air and electrical power can also be provided to the start-up module 18 from the MCC as illustrated in FIG. 16. The inlet module 14 can also be configured to include the steam letdown valve 80 in the central length of the expansion loop 40 and the air and control lines 50, 54 are connected to the letdown air and control module 80 in the start-up module 18. The start-up liquid line 44 and the start-up vapour line 46 can also be connected from the start-up module 18 to the inlet module 14 to enable the start-up fluids (*i.e.* the vapours and liquids collected during steam circulation) to be transported to the CPF.

[00118] The start-up phase can then commence utilizing the start-up module 18, inlet module 14 and well pair module(s) 20 configured temporarily, as detailed above. As well pairs 22, 24 become ready for the production phase, the well pair module 20 can be further configured to utilize the emulsion group line 34 and emulsion test line 35 to transport production fluids to the inlet module 14, which transport the entire stream to the CPF. The well pairs 22, 24 that are still in the start-up phase can continue to carry the start-up liquids to the inlet module 14 with any production gases being fed into this stream and separated by the start-up module 18 while the start-up module is still being used. Once all well pairs 22, 24 have completed start-up, the well pair modules 20 are configured to operate fully in the production phase to send the emulsion group stream and emulsion test streams to the inlet module 14 as explained above. The temporary connections between the inlet module 14 and the start-up module 18 can be removed and the start-up module 18 itself removed from the modular system 10. The start-up module 18 is then available to be used at another well pad site 12 or otherwise be removed from the current well pad site 12. Moreover, after being set up in a start-up configuration, if the well pair module 20 can achieve (or complete) fluid communication between the injection and

production wells 22, 24 using steam bullheading, the start-up module 18 can be removed at an earlier stage and moved to another site.

[00119] For simplicity and clarity of illustration, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the examples described herein. However, it will be understood by those of ordinary skill in the art that the examples described herein may be practiced without these specific details. In other instances, well-known methods, procedures and components have not been described in detail so as not to obscure the examples described herein. Also, the description is not to be considered as limiting the scope of the examples described herein.

[00120] It will be appreciated that the examples and corresponding diagrams used herein are for illustrative purposes only. Different configurations and terminology can be used without departing from the principles expressed herein. For instance, components and modules can be added, deleted, modified, or arranged with differing connections without departing from these principles.

[00121] Although the above principles have been described with reference to certain specific examples, various modifications thereof will be apparent to those skilled in the art as outlined in the appended claims.

Claims:

1. A module used during a start-up phase in a steam assisted gravity drainage (SAGD) process, the module comprising a transportable frame configured to be detachably coupled to operating facilities at a well pad site temporarily for a start-up phase, the transportable frame supporting start-up operations equipment for implementing the start-up phase; wherein the start-up operations equipment are supported by the transportable frame to connect to and temporarily configure the operating facilities to implement the start-up phase, be disconnected from the operating facilities, and be removed from the well pad site thereafter; wherein the start-up operations equipment temporarily connect to: a steam line that provides steam during the start-up phase, one or more flow lines to receive start-up fluids from one or more wells, and to a processing facility to transport the start-up fluids thereto.
2. The module of claim 1, wherein the operating facilities at the well pad site comprise at least a first flow line corresponding to the steam line for providing the steam to the one or more wells, a second flow line for providing fuel gas to one or more wells, a third flow line for transporting production fluids to the processing facility, and a fourth flow line for transporting production gas to the processing facility.
3. The module of claim 2, wherein the second flow line corresponds to a fuel gas line, the third flow line corresponds to an emulsion line, and the fourth flow line corresponds to a production gas line.
4. The module of claim 2 or claim 3, wherein the start-up operations equipment comprises:
 - a steam separator detachably coupled to:
 - the fourth flow line configured to transport start-up fluids comprising steam vapour and steam condensate from a first well to surface during a start-up phase, and
 - the second flow line for operating the steam separator, the steam separator configured for separating the steam vapour from the steam condensate;
 - a condensate separator coupled to the steam separator for receiving the steam condensate separated from the start-up fluids, the condensate separator configured for separating steam condensate from non-condensable gas, and for

transporting start-up vapours containing the non-condensable gas to the processing facility;

a cooler coupled to the steam separator and the condensate separator for receiving and cooling the steam vapour separated from the start-up fluids to generate additional steam condensate, and providing the additional steam condensate to the condensate separator; and

at least one pump for pumping the start-up liquids to the processing facility.

5. The module of claim 4, wherein the first well is used in a production phase as a production well to receive an emulsion from the reservoir.
6. The module of any one of claims 1 to 4, wherein the operating facilities are configured to implement the start-up phase by providing steam to at least one of an injection well and a production well.
7. The module of claim 6, wherein the steam is provided to both the injection well and the production well.
8. The module of claim 7, wherein the operating facilities are configured to circulate the steam at both the injection well and the production well during the start-up phase.
9. The module of any one of claims 1 to 8, wherein a steam letdown valve is used to reduce steam pressure to one or more wells at the well pad site during the start-up phase operated by the start-up operations equipment.
10. The module of any one of claims 2 to 5, wherein the start-up liquids are pumped to the processing facility via the third flow line, and the start-up vapours are transported to the processing facility via the fourth flow line.
11. The module of any one of claims 1 to 10, further comprising a local motor control centre (MCC) for providing power and control operations to the module, the local MCC being connected to a site MCC used by the operating facilities.

12. The module of claim 11, wherein the local MCC is connected to instrument air and an electrical power line provided by the site MCC.
13. The module of any one of claims 4 to 12, wherein the cooler is supported atop the transportable frame and is installed thereon subsequent to the frame being transported to the well pad site.
14. The module of any one of claims 4 to 13, wherein the steam separator is temporarily coupled to the second flow line via a flexible connection to provide fuel for operating the steam separator.
15. The module of any one of claims 4 to 14, wherein the steam separator is temporarily coupled to the fourth flow line for receiving the start-up fluids from a first well during the start-up phase, via a flexible connection.
16. The module of any one of claims 9 to 15, wherein instrument air is connected to the steam letdown valve for controlling operation of the steam letdown valve.
17. The module of any one of claims 9 to 16, wherein the steam let down valve is temporarily installed in a portion of the first flow line.
18. The module of claim 17, wherein the portion of the first flow line is part of an expansion loop having a central length to detachably receive the steam letdown valve during the start-up phase and a pipe length during a production phase.
19. The module of any one of claims 1 to 18, wherein at least one component of the start-up operating equipment is supported above at least one other component of the start-up operating equipment.
20. The module of any one of claims 1 to 19, wherein the transportable frame is sized similar to an Alberta sized module to enable roadway transportation thereof.
21. The module of any one of claims 9 to 20, wherein the operating facilities comprise an inlet module coupled to the module used during the start-up phase, and at least one well pair

module coupled to the inlet module for interfacing with the one or more wells, the inlet module being configured to interface with the start-up module to provide the fuel gas and the start-up fluids and to receive the start-up liquids and start-up vapours, the at least one well pair module being configured to operate using steam output from the steam let down valve and to transport start-up fluids to the inlet module during the start-up phase.

22. A method for implementing a start-up phase in a steam assisted gravity drainage (SAGD) process, the method comprising:

- locating a module comprising a transportable frame adjacent to at least one component of operating facilities at a well pad site;

- connecting the module to a steam let down valve interposed in a steam line for reducing steam pressure during the start-up phase;

- configuring one or more wells to circulate steam for implementing the start-up phase;

- connecting the module to the operating facilities to receive start-up fluids from the one or more wells, the start-up fluids comprising steam vapour and steam condensate from a first well to surface;

- configuring a steam separator in the module to separate start-up fluids into the steam vapour and the steam condensate;

- initiating the start-up phase using steam processed by the steam letdown valve;

- receiving start-up fluids from the operating facilities; and

- operating start-up operations equipment supported by the transportable frame, to separate the start-up fluids, pump the start-up fluids to a processing facility, and transport start-up vapours containing non-condensable gas to the processing facility.

23. The method of claim 22, further comprising decoupling the transportable frame from the operating facilities after the start-up phase.

24. The method of claim 22 or claim 23, wherein the operating facilities at the well pad site comprise at least a first flow line for providing steam to one or more wells, a second flow line for providing fuel gas to one or more wells, a third flow line for transporting production fluids to a processing facility, and a fourth flow line for transporting production gas to the processing facility.

25. The method of claim 24, wherein the start-up liquids are pumped to the processing facility via the third flow line, and the start-up vapours are transported to the processing facility via the fourth flow line.
26. The method of any one of claims 22 to 25, further comprising connecting a local motor control centre (MCC) to a site MCC used by the operating facilities, for providing power and control operations to the module.
27. The method of claim 26, wherein the local MCC is connected to instrument air and an electrical power line provided by the site MCC.
28. The method of any one of claims 22 to 27, wherein the start-up operations equipment comprises a cooler for receiving and cooling the steam vapour separated from the start-up fluids to generate additional steam condensate, the method further comprising supporting a cooler atop the transportable frame subsequent to the frame being transported to the well pad site.
29. The method of any one of claims 24 to 28, further comprising temporarily coupling a steam separator to the second flow line via a flexible connection.
30. The method of any one of claims 24 to 29, further comprising temporarily connecting a steam separator to the fourth flow line for receiving the start-up fluids during the start-up phase, via a flexible connection.
31. The method of any one of claims 22 to 30, wherein instrument air is connected to the steam letdown valve for controlling operation of the steam letdown valve.
32. The method of any one of claims 22 to 31, wherein the steam let down valve is temporarily installed in a portion of the first flow line.
33. The method of claim 32, wherein the portion of the first flow line is part of an expansion loop having a central length to detachably receive the steam letdown valve during the start-up phase and a pipe length during a production phase.

34. The method of any one of claims 22 to 33, wherein at least one component of the start-up operating equipment is supported above at least one other component of the start-up operating equipment.
35. The method of any one of claims 22 to 34, wherein the transportable frame is sized similar to an Alberta sized module to enable roadway transportation thereof.
36. The method of any one of claims 24 to 35, wherein the operating facilities comprise an inlet module coupled to the module used during the start-up phase, and at least one well pair module coupled to the inlet module for interfacing with the one or more wells, the inlet module being configured to interface with the start-up module to provide the fuel gas and the start-up fluids and to receive the start-up liquids and start-up vapours, the at least one well pair module being configured to operate using steam output from the steam let down valve and to transport start-up fluids to the inlet module during the start-up phase.
37. The method of any one of claims 24 to 36, wherein the first flow line corresponds to a steam line, the second flow line corresponds to a fuel gas line, the third flow line corresponds to an emulsion line, and the fourth flow line corresponds to a production gas line.
38. The method of any one of claims 22 to 37, wherein the first well is used in a production phase as a production well to receive an emulsion from the reservoir.
39. The method of any one of claims 22 to 38, wherein the operating facilities are configured to implement the start-up phase by providing steam to at least one of an injection well and a production well.
40. The method of claim 39, wherein the steam is provided to both the injection well and the production well.
41. The method of claim 40, wherein the operating facilities are configured to circulate the steam at both the injection well and the production well during the start-up phase.

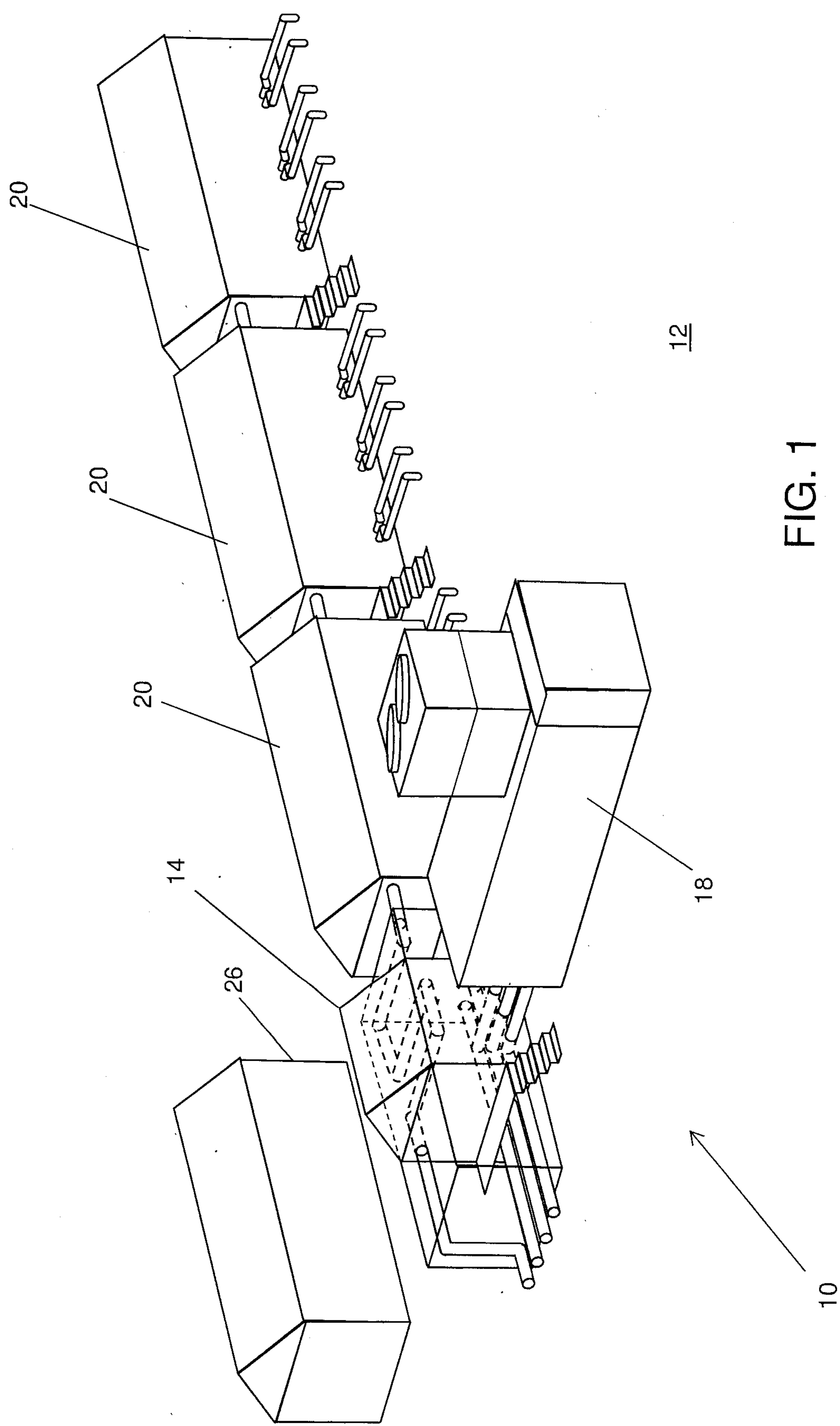


FIG. 1

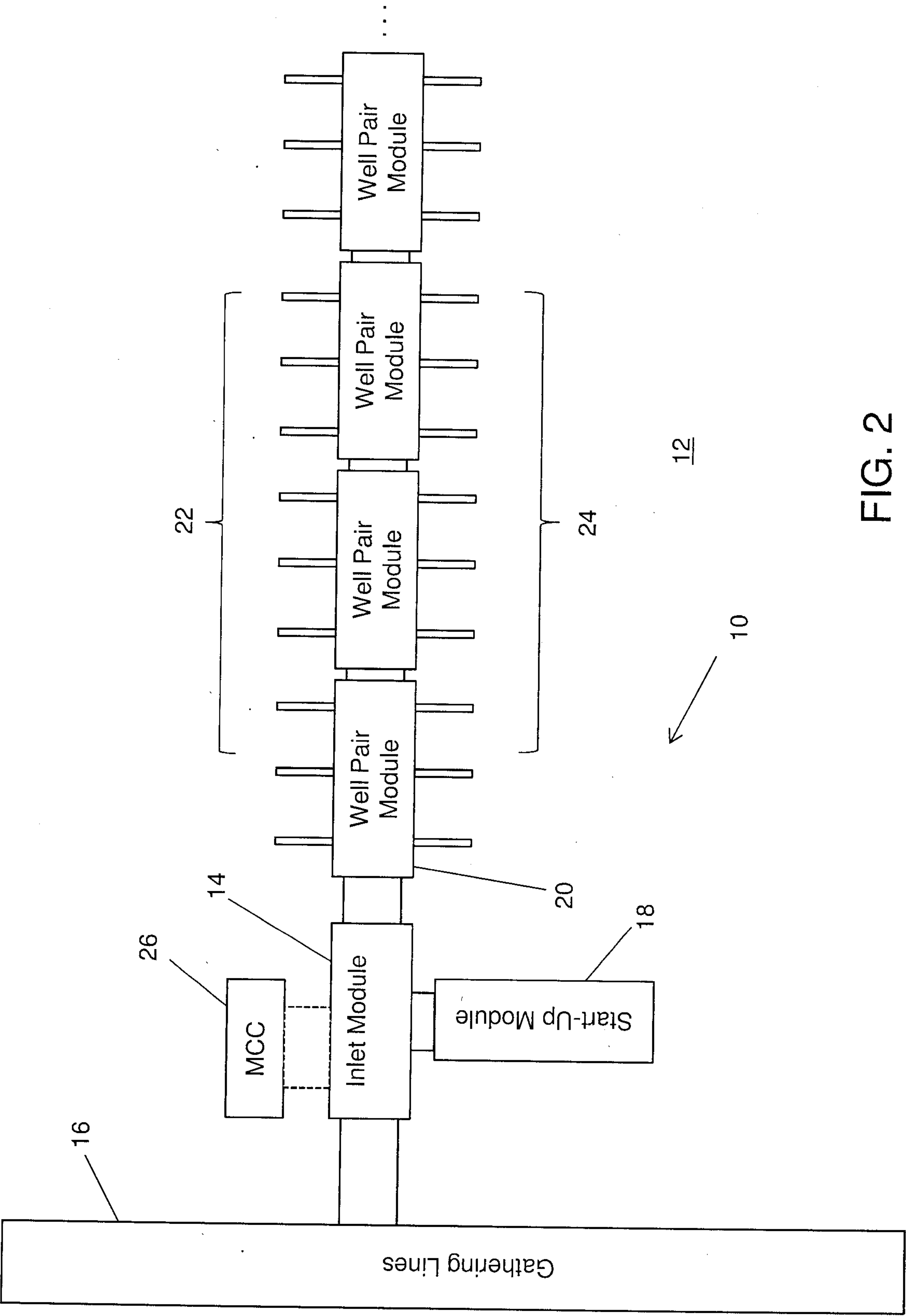
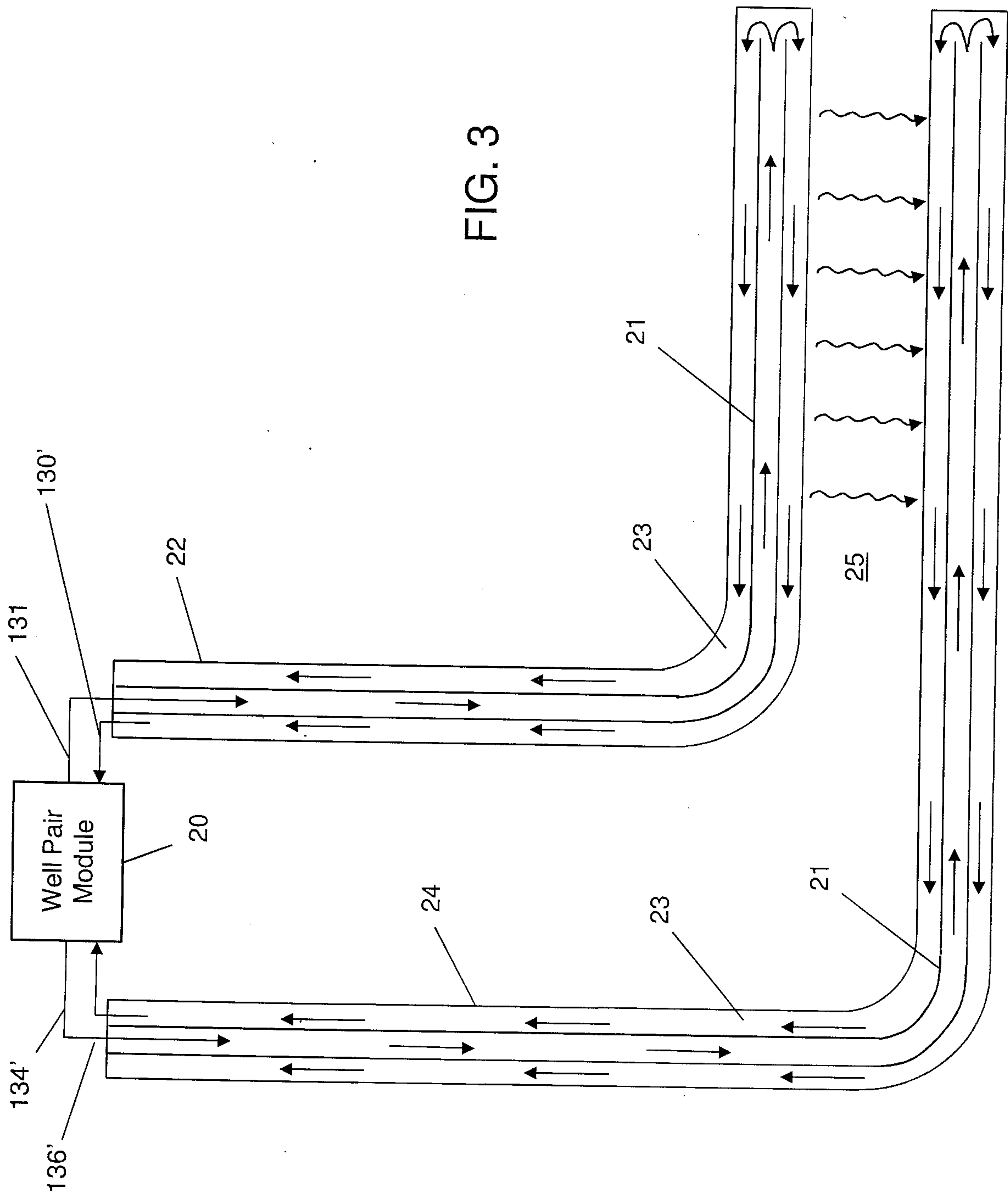


FIG. 2



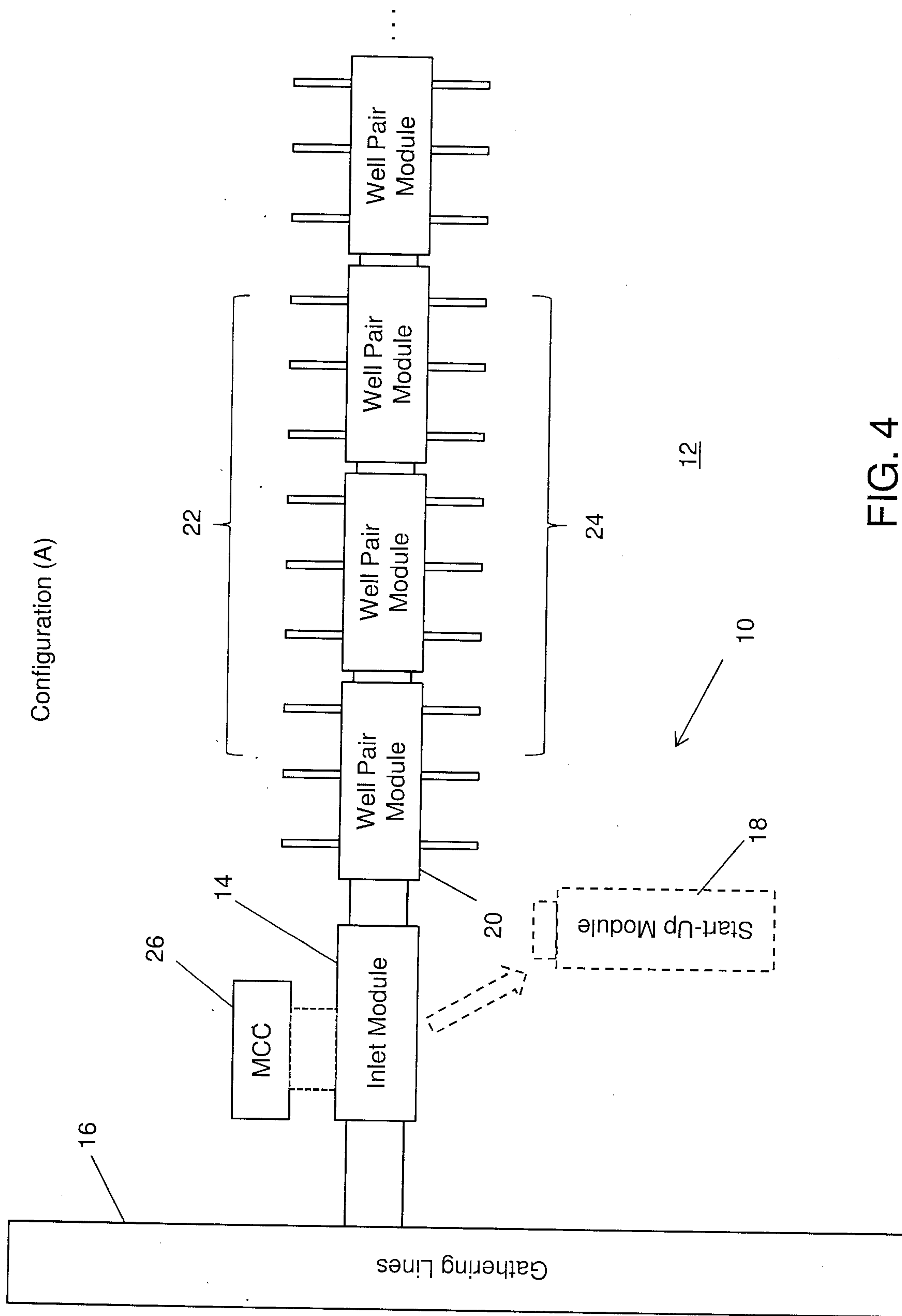


FIG. 4

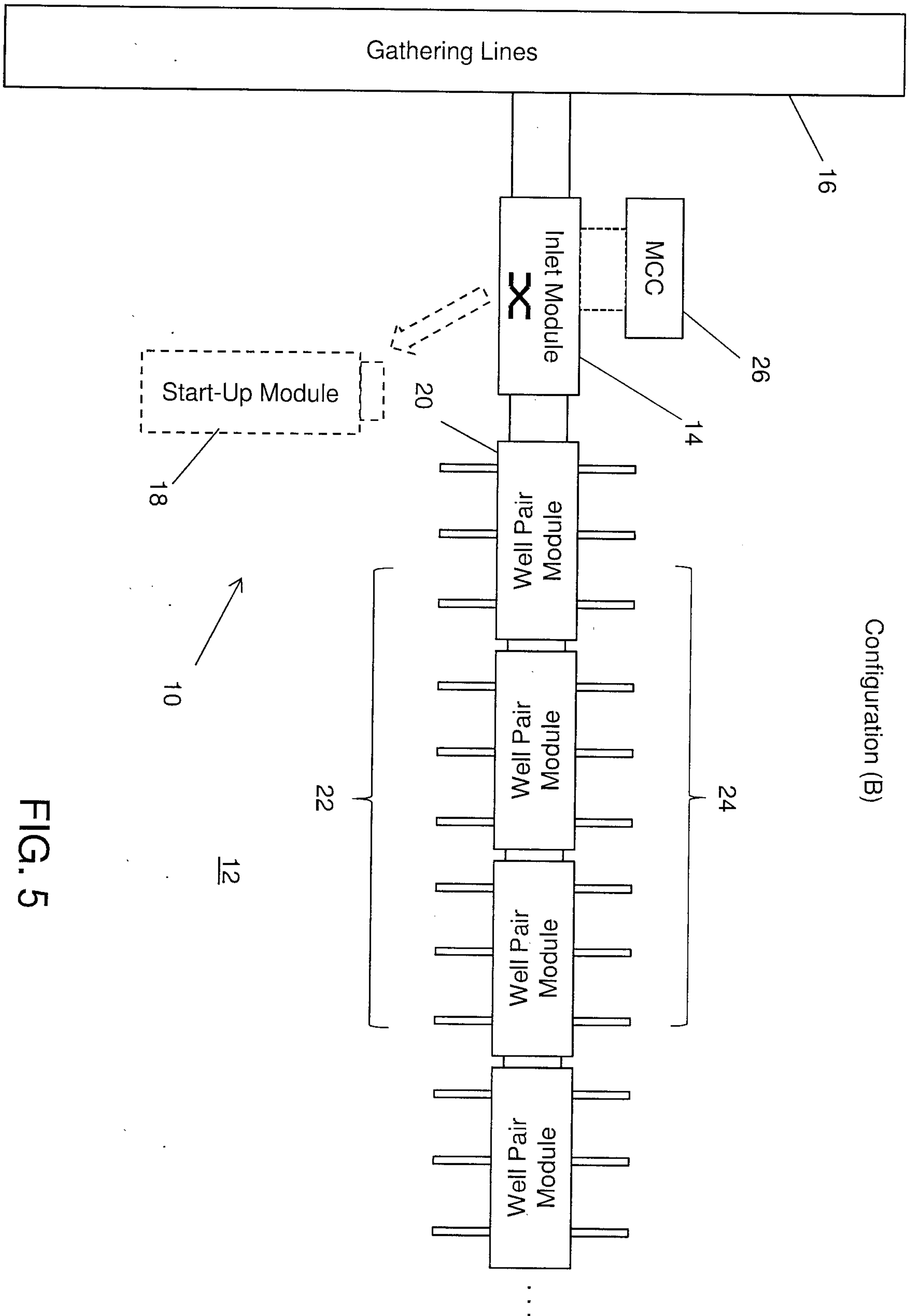


FIG. 5

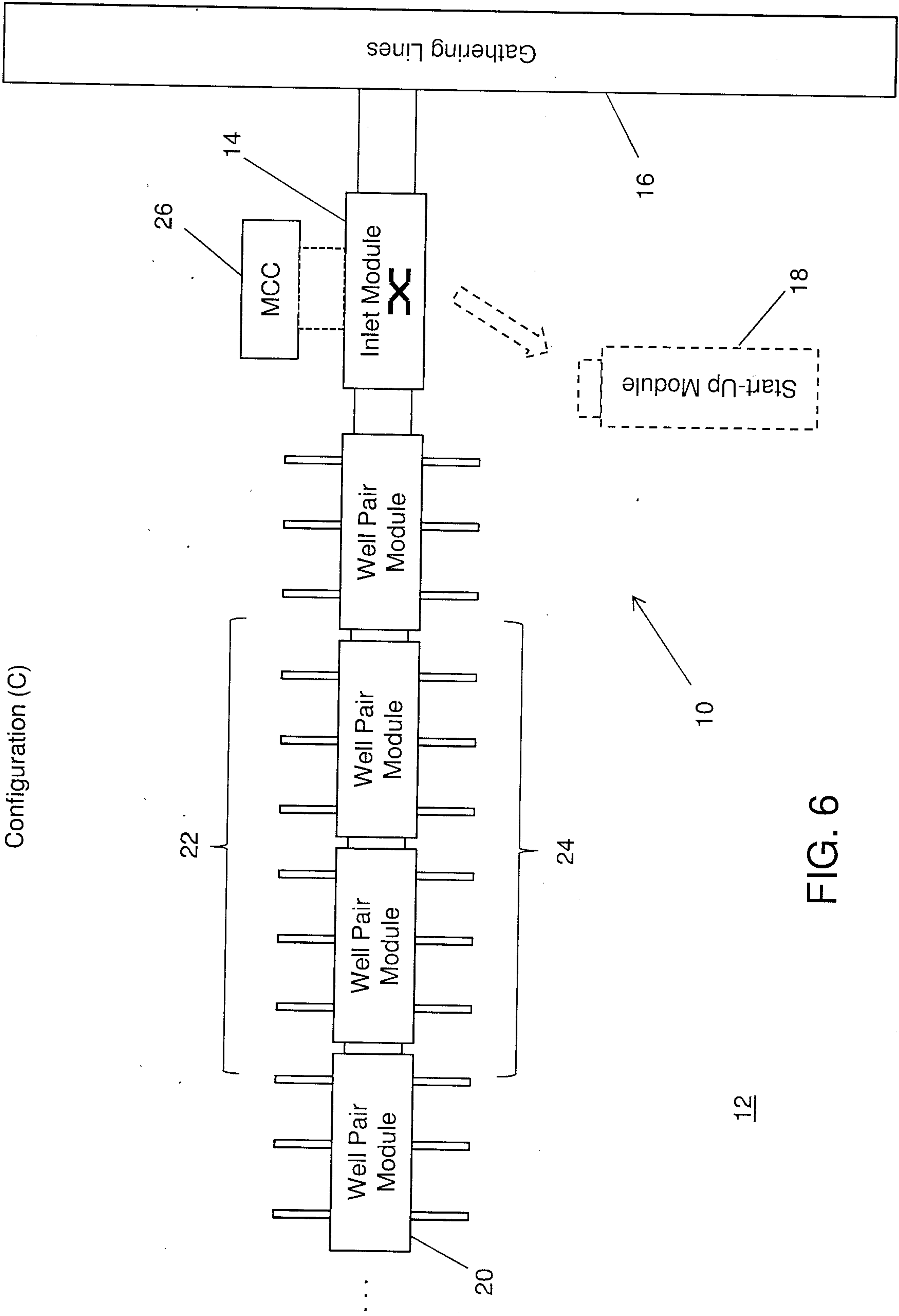


FIG. 6

Configuration (D)

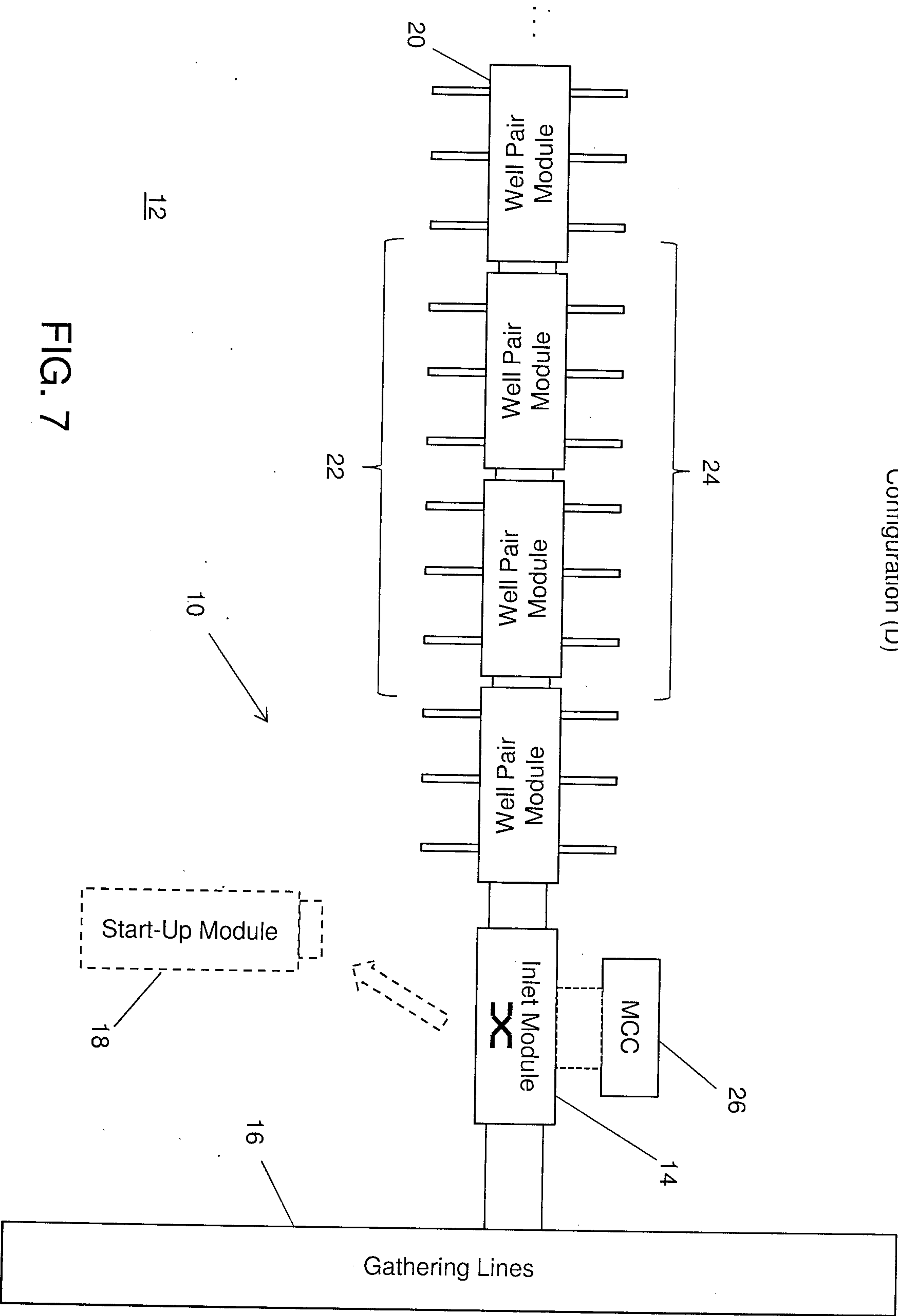


FIG. 7

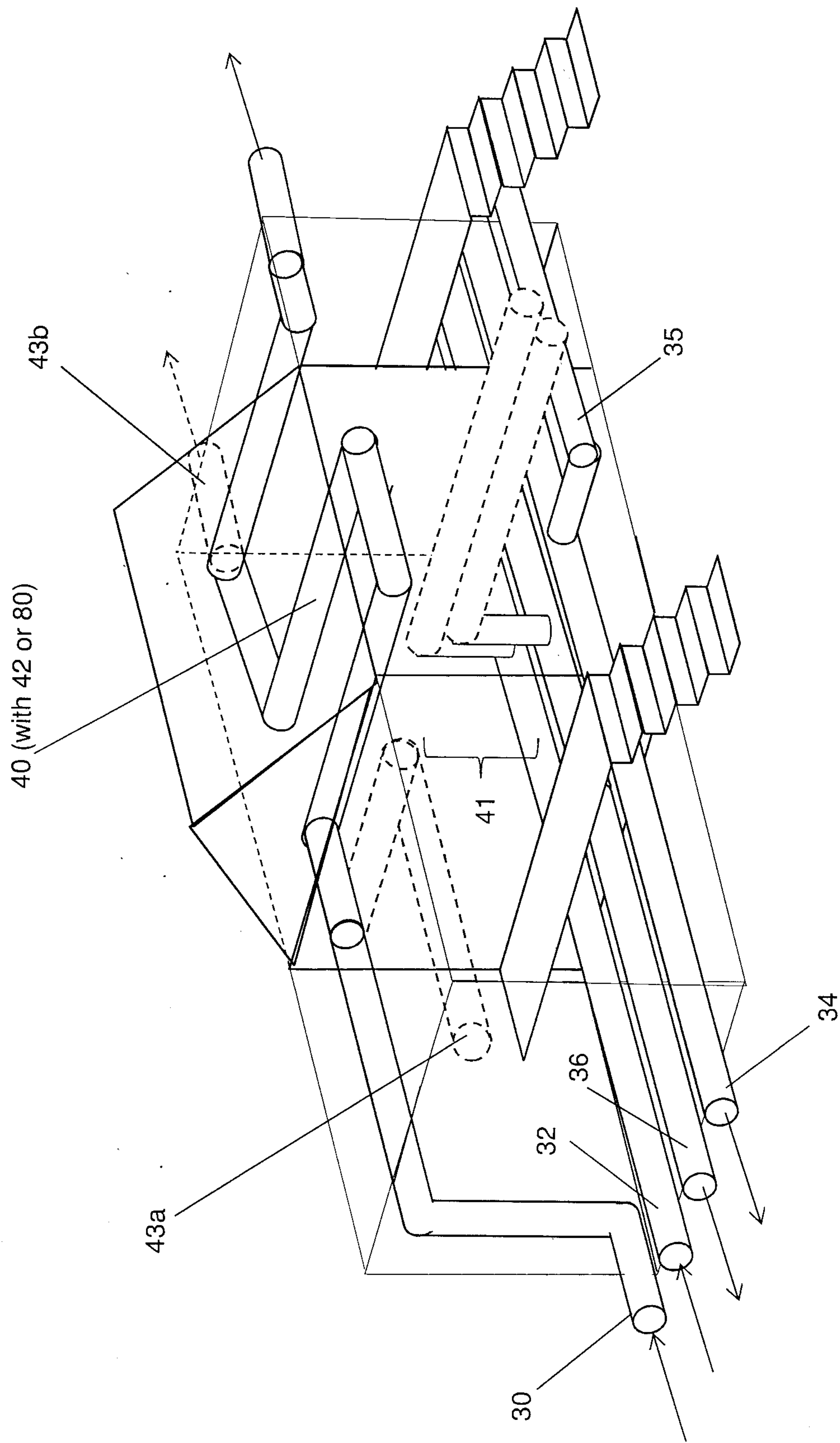


FIG. 8

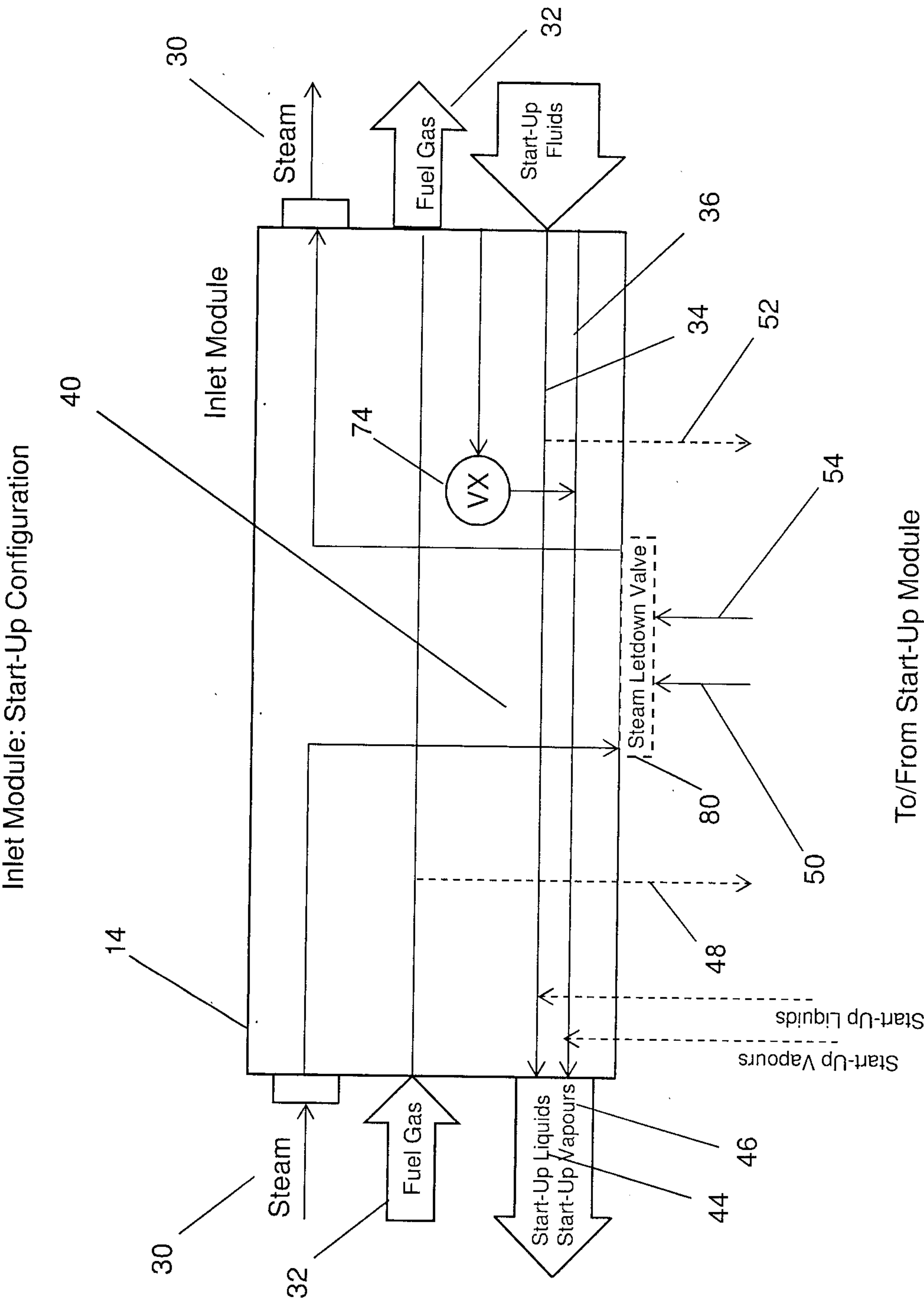


FIG. 9

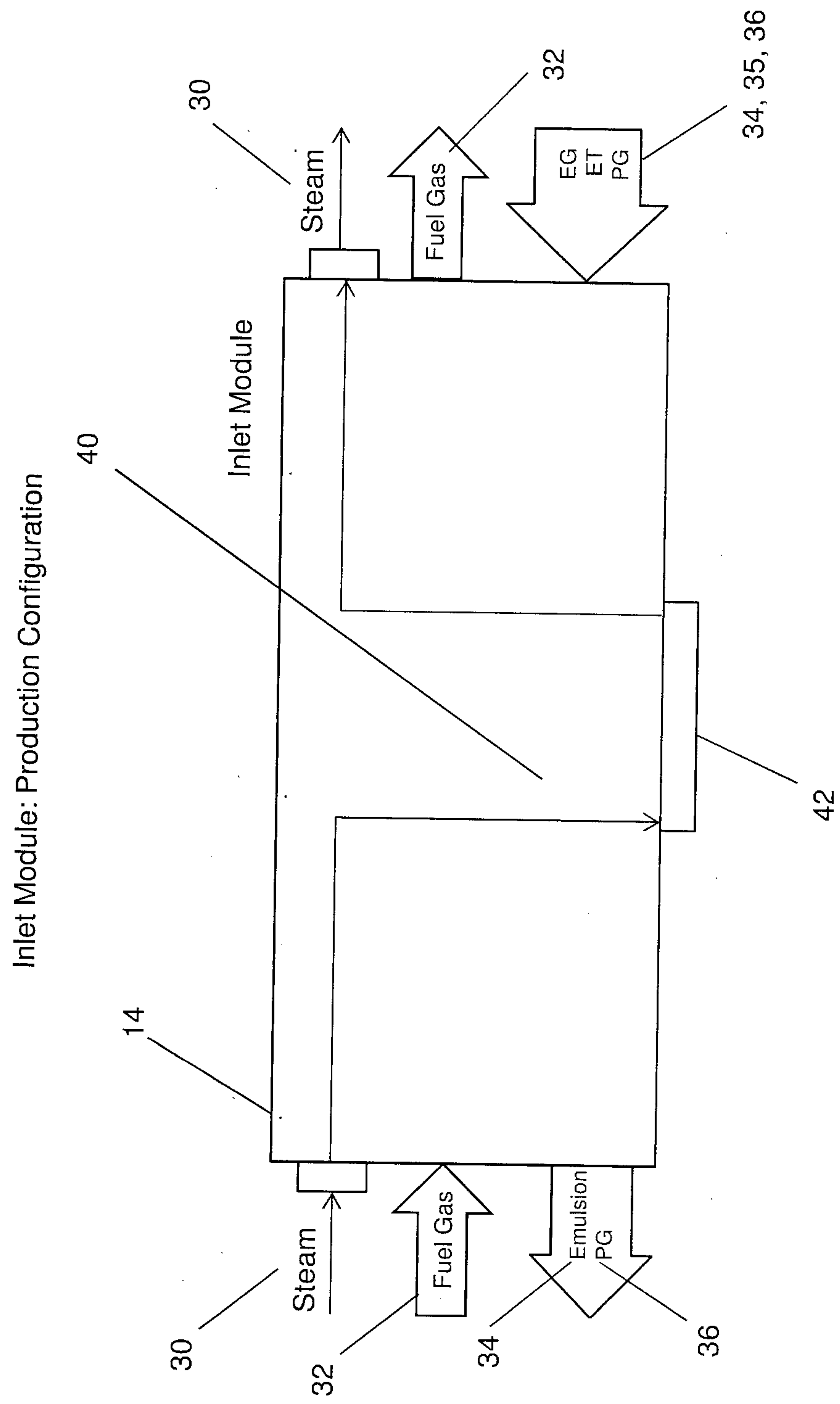


FIG. 10

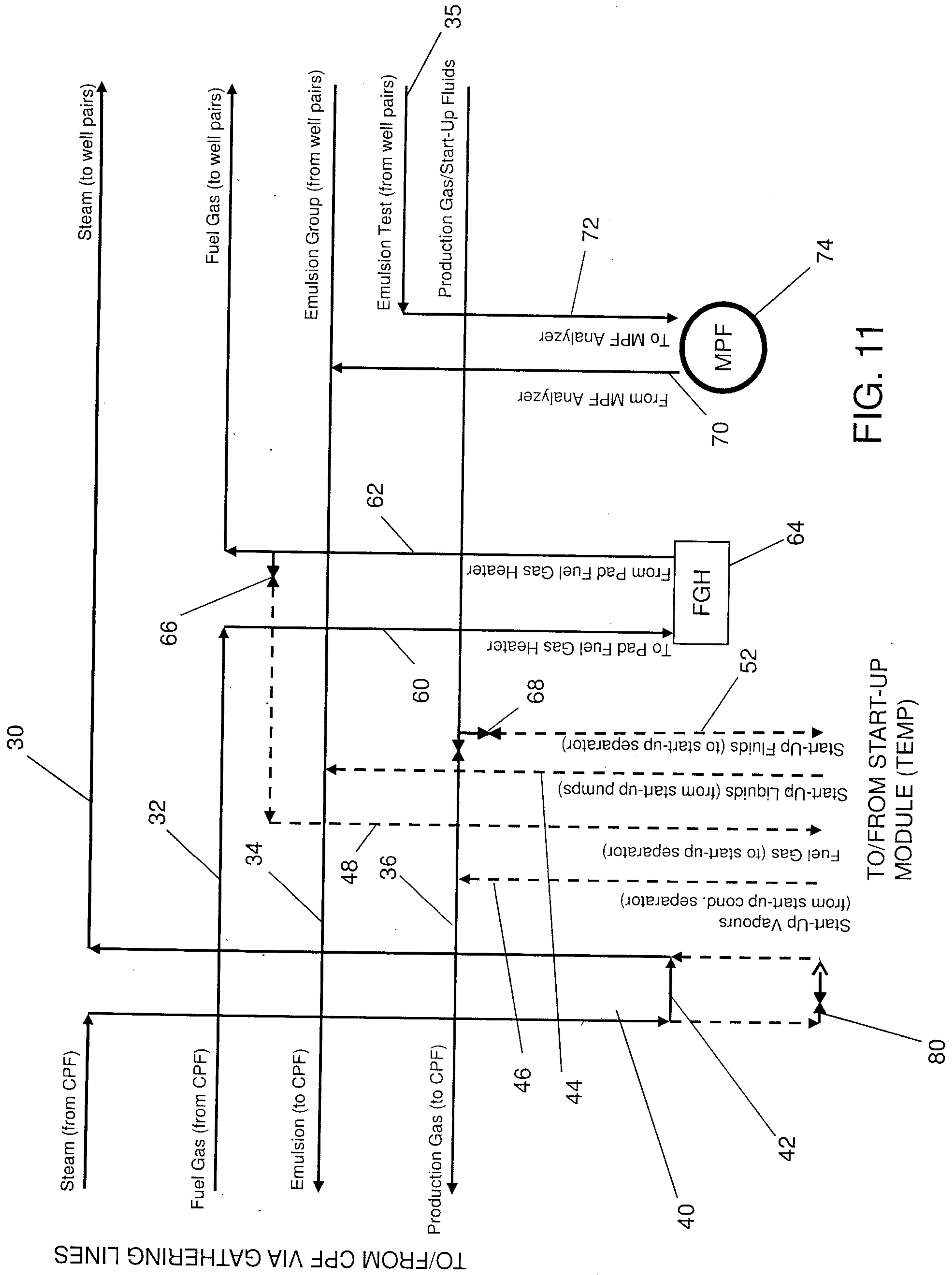


FIG. 11

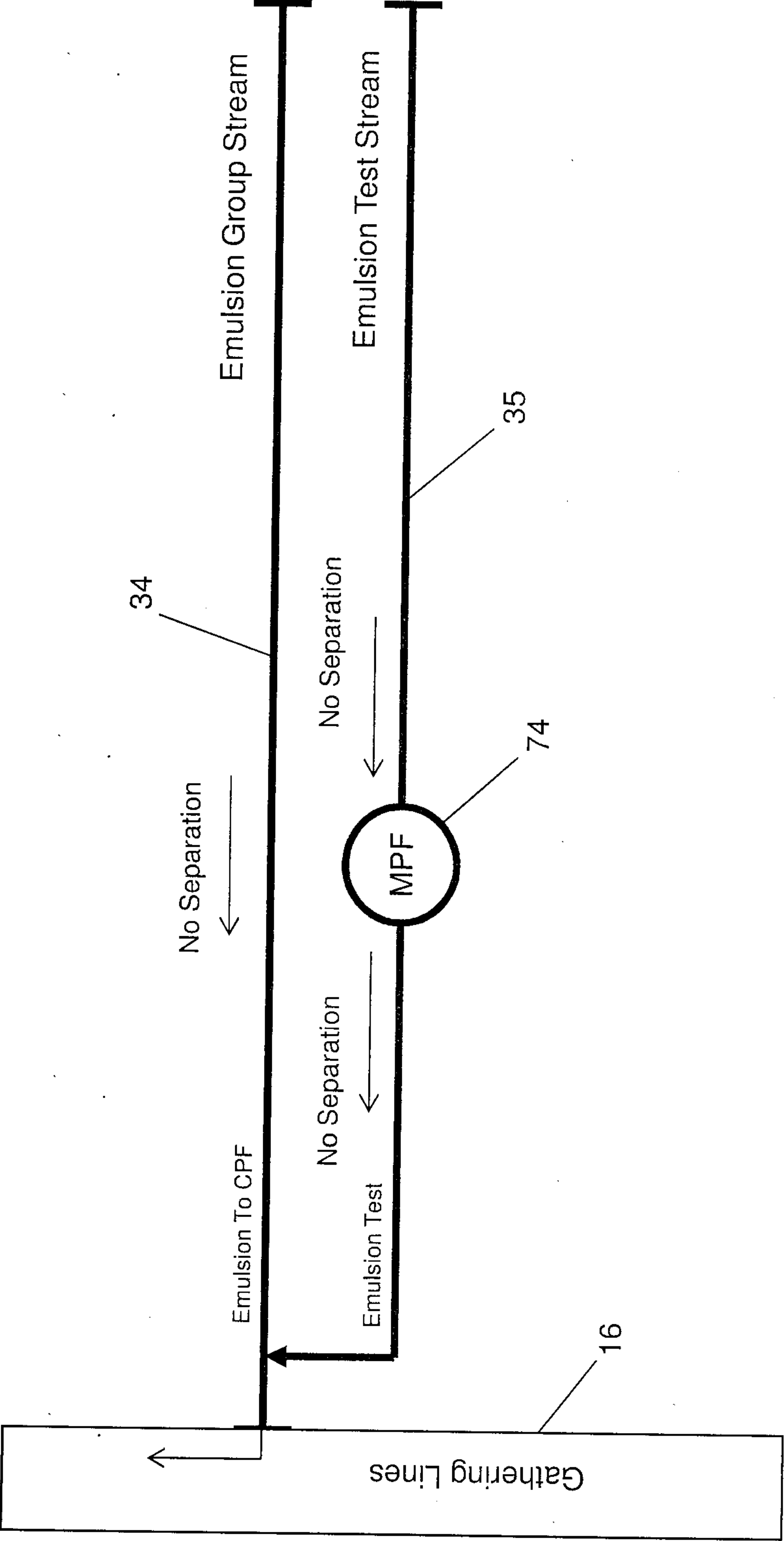


FIG. 12

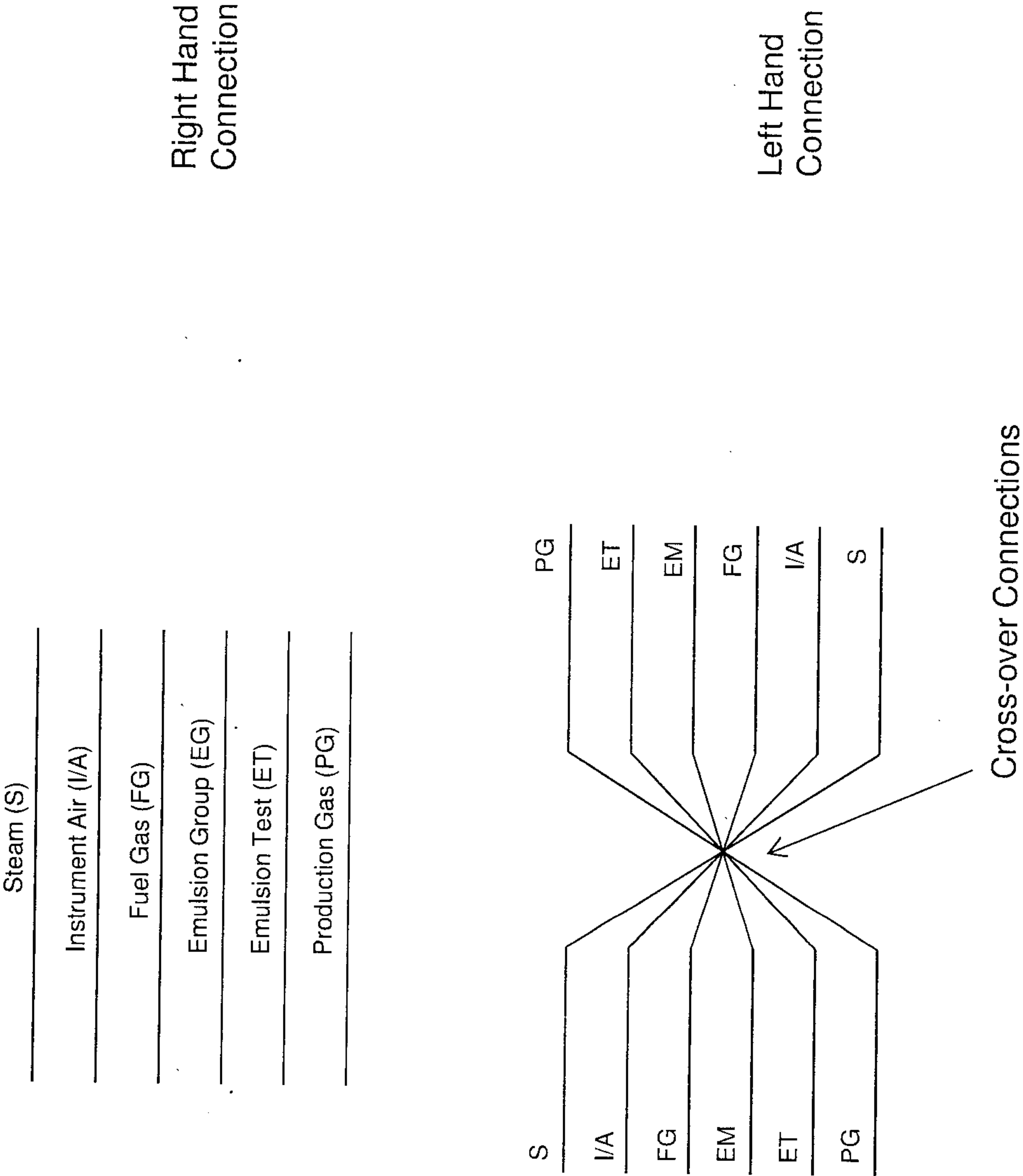


FIG. 13

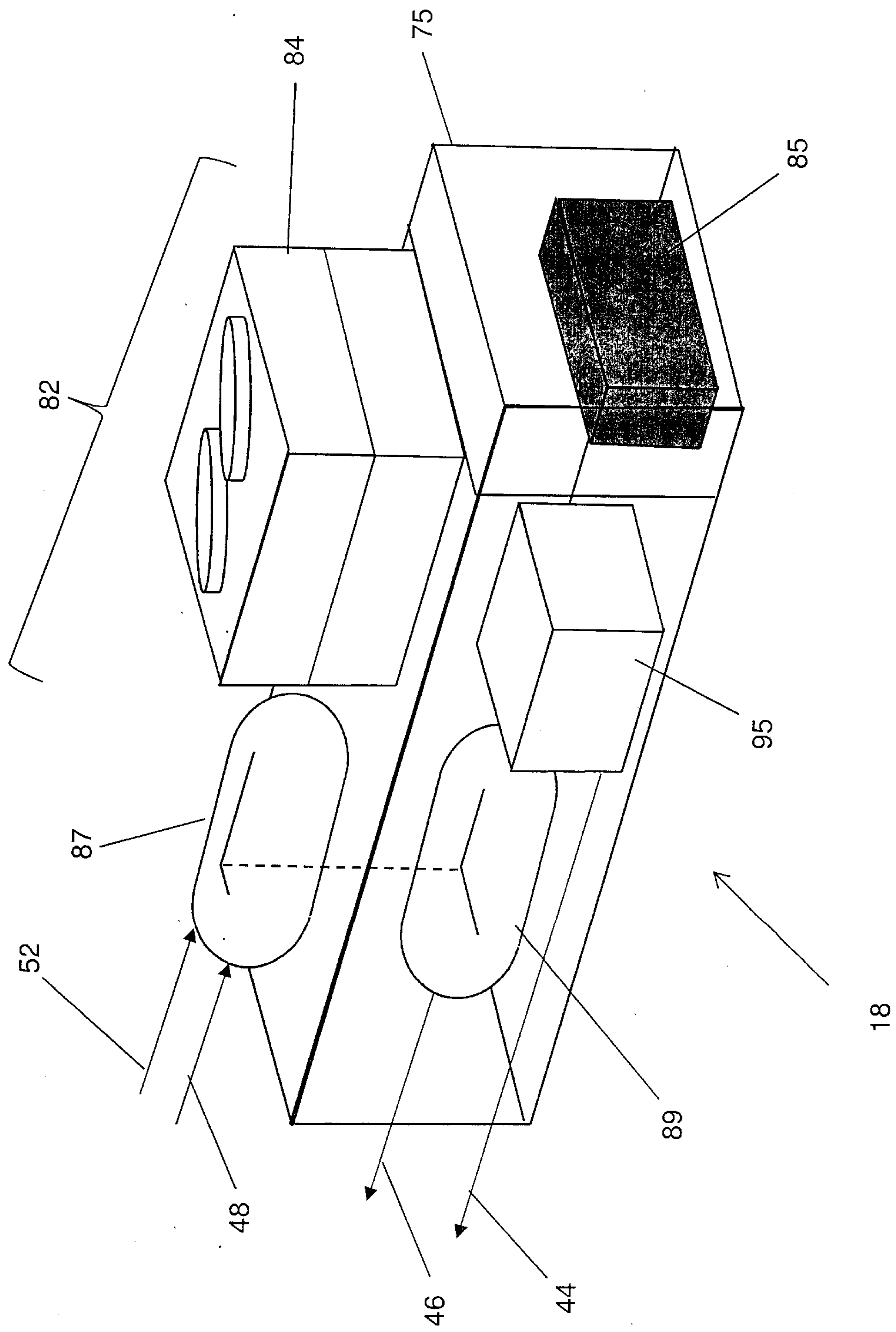


FIG. 14

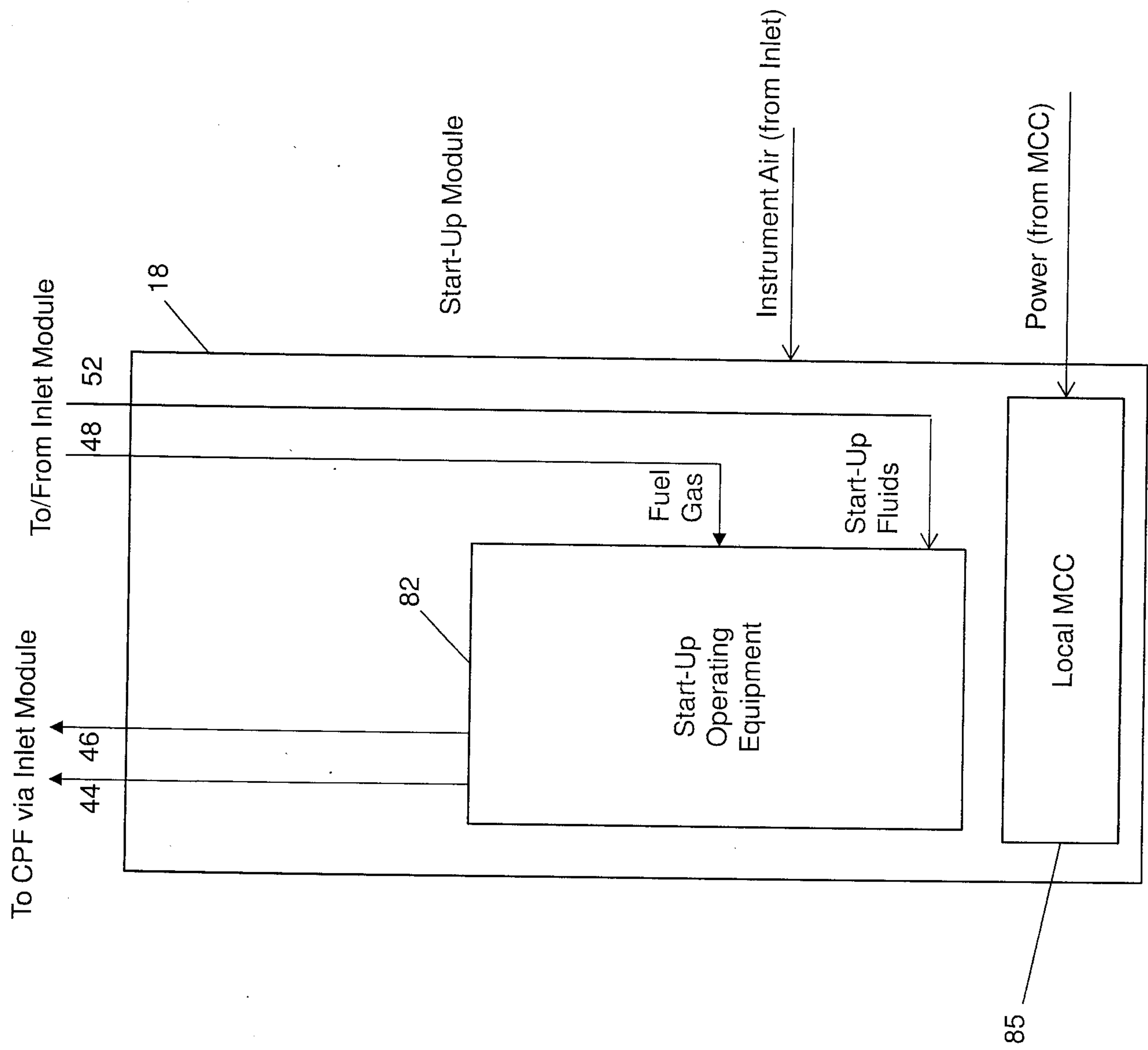


FIG. 15

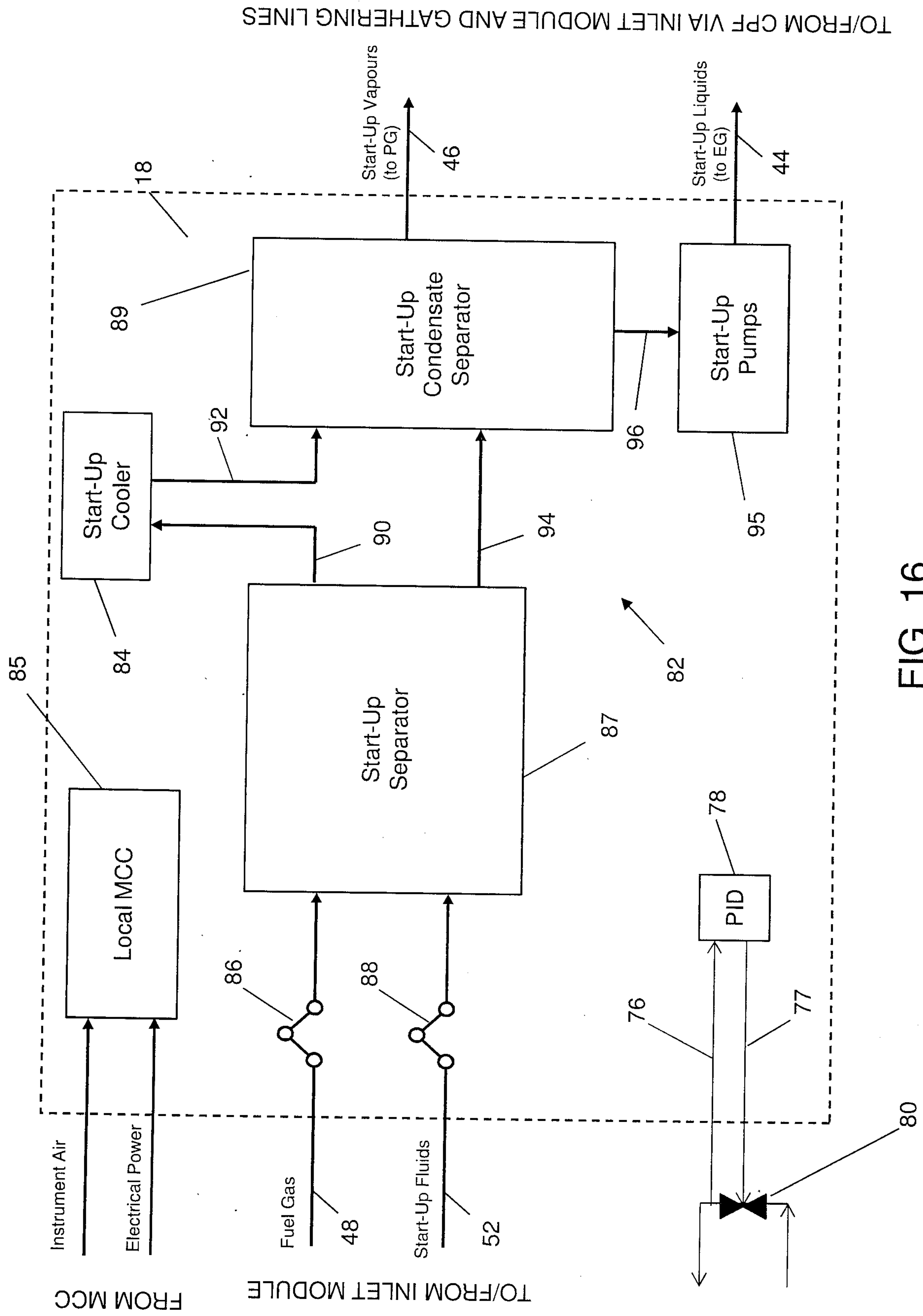


FIG. 16

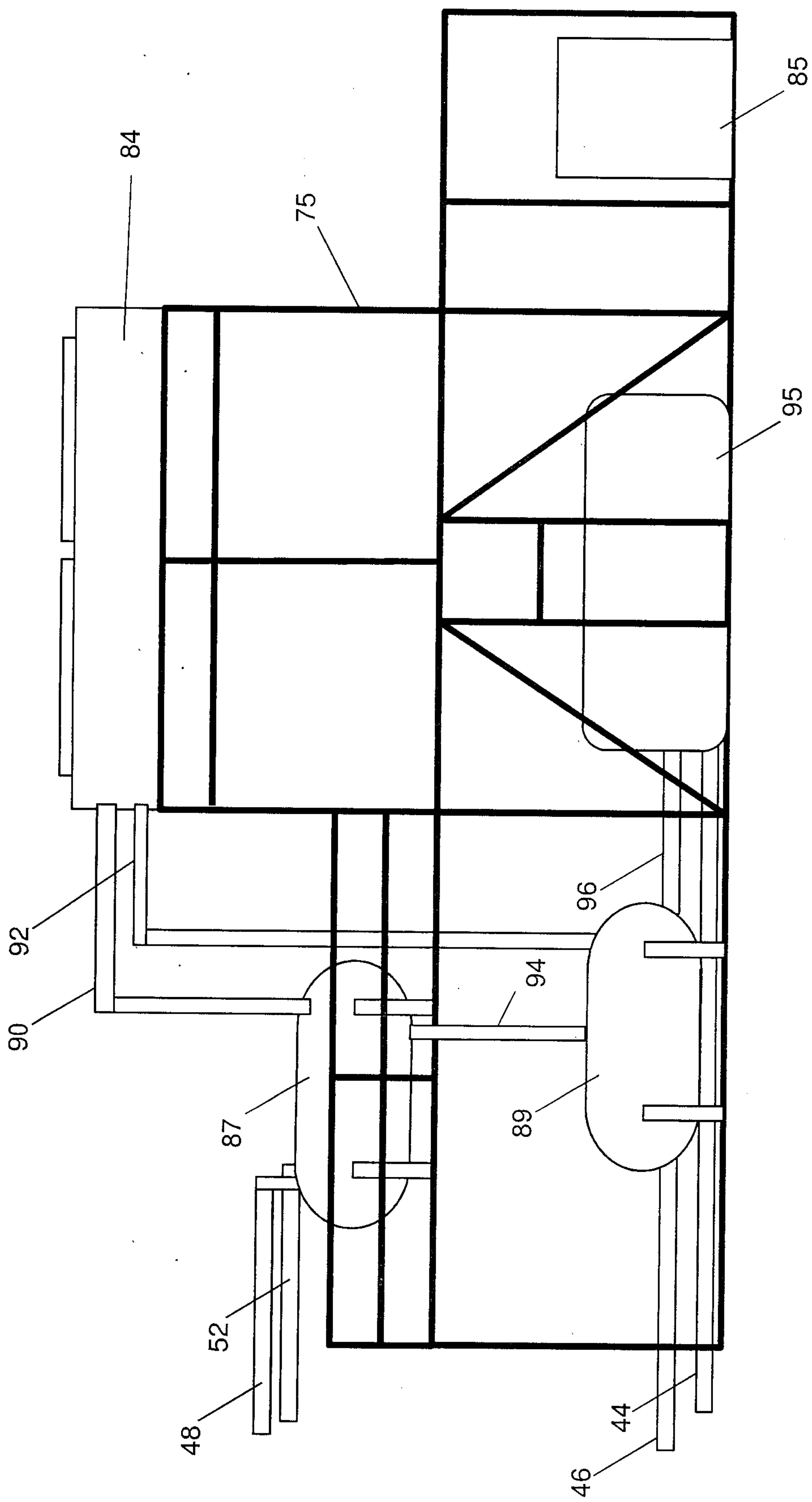


FIG. 17

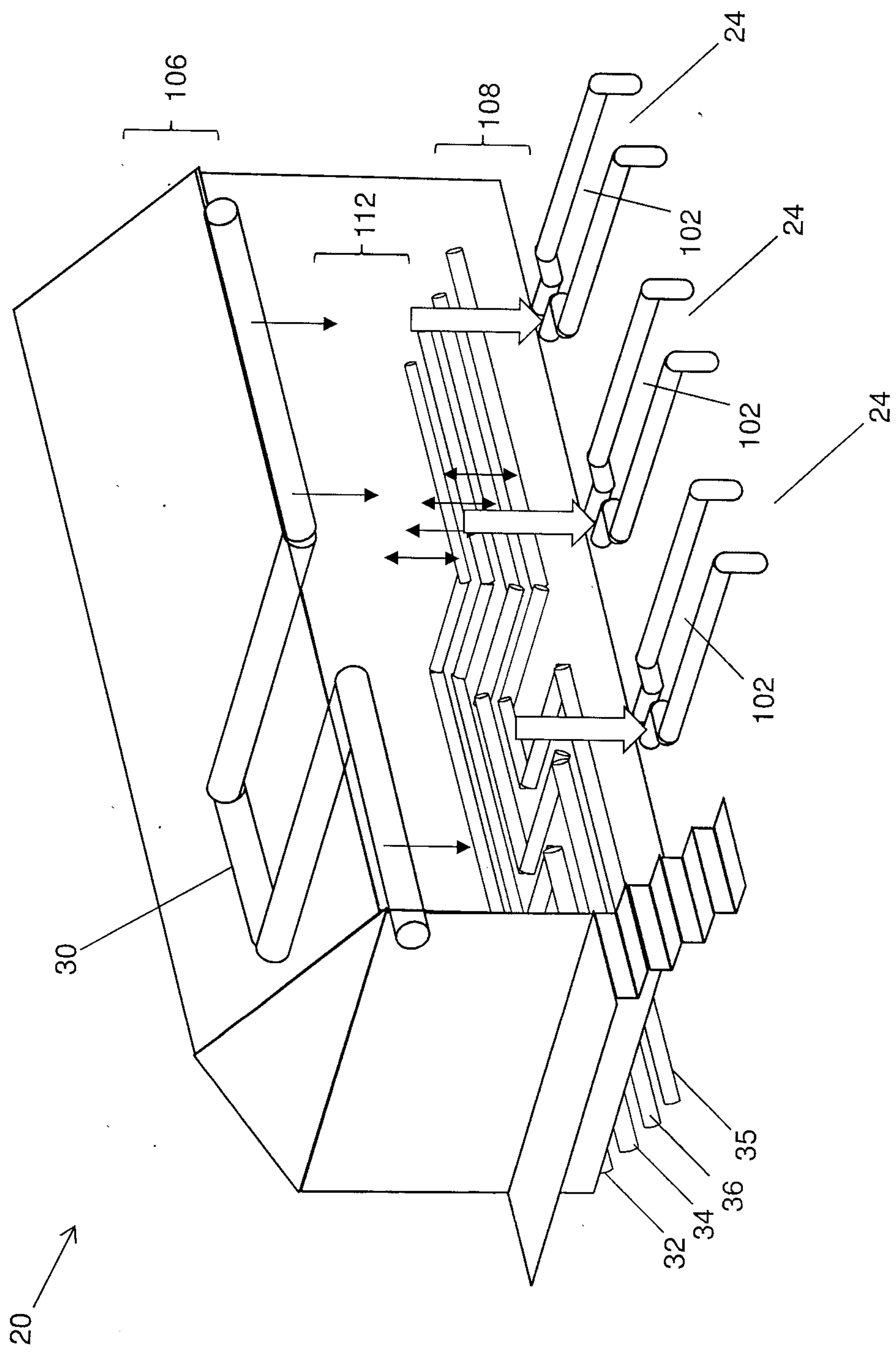


FIG. 18

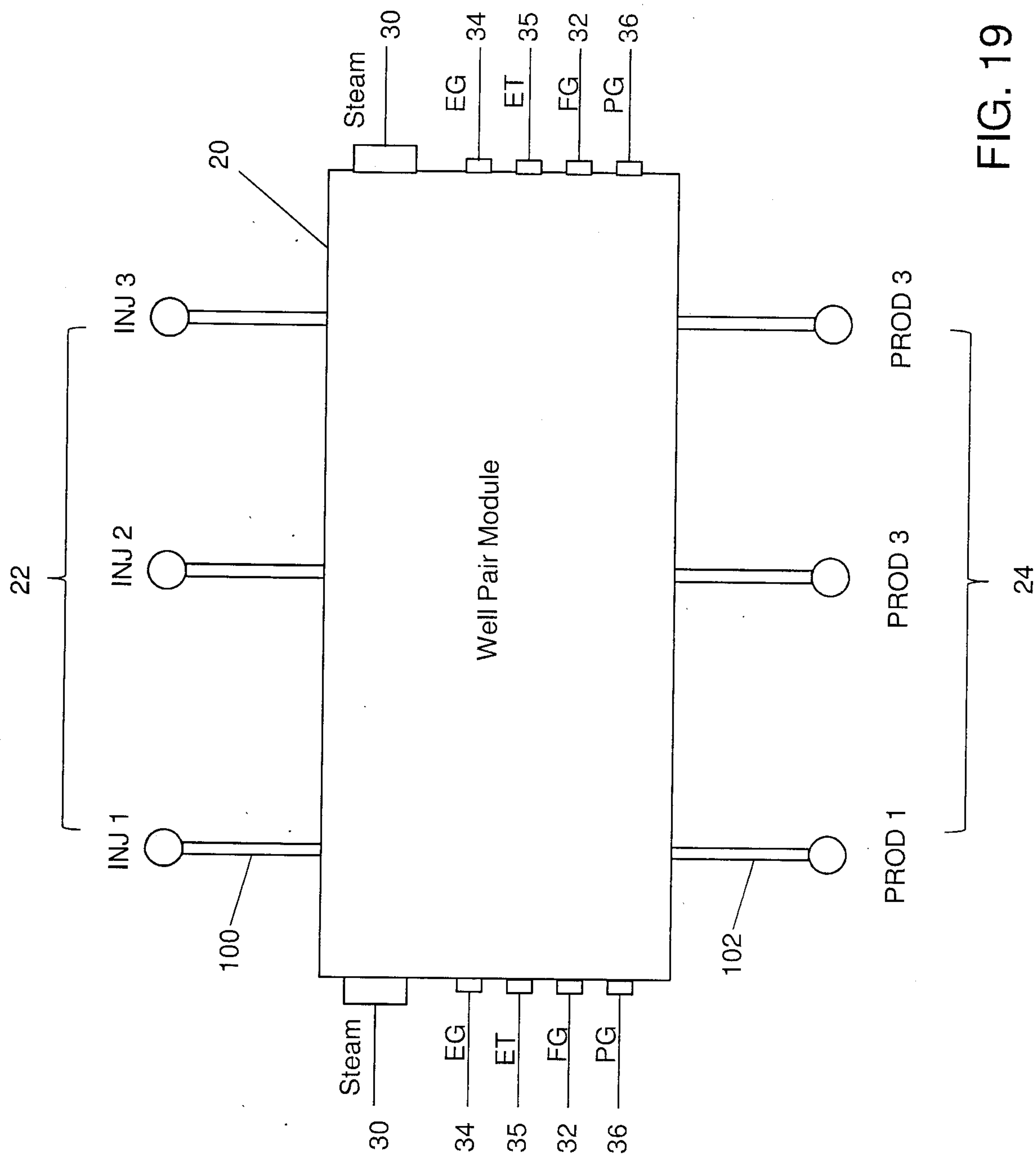


FIG. 19

Well Pair Module – Production Phase

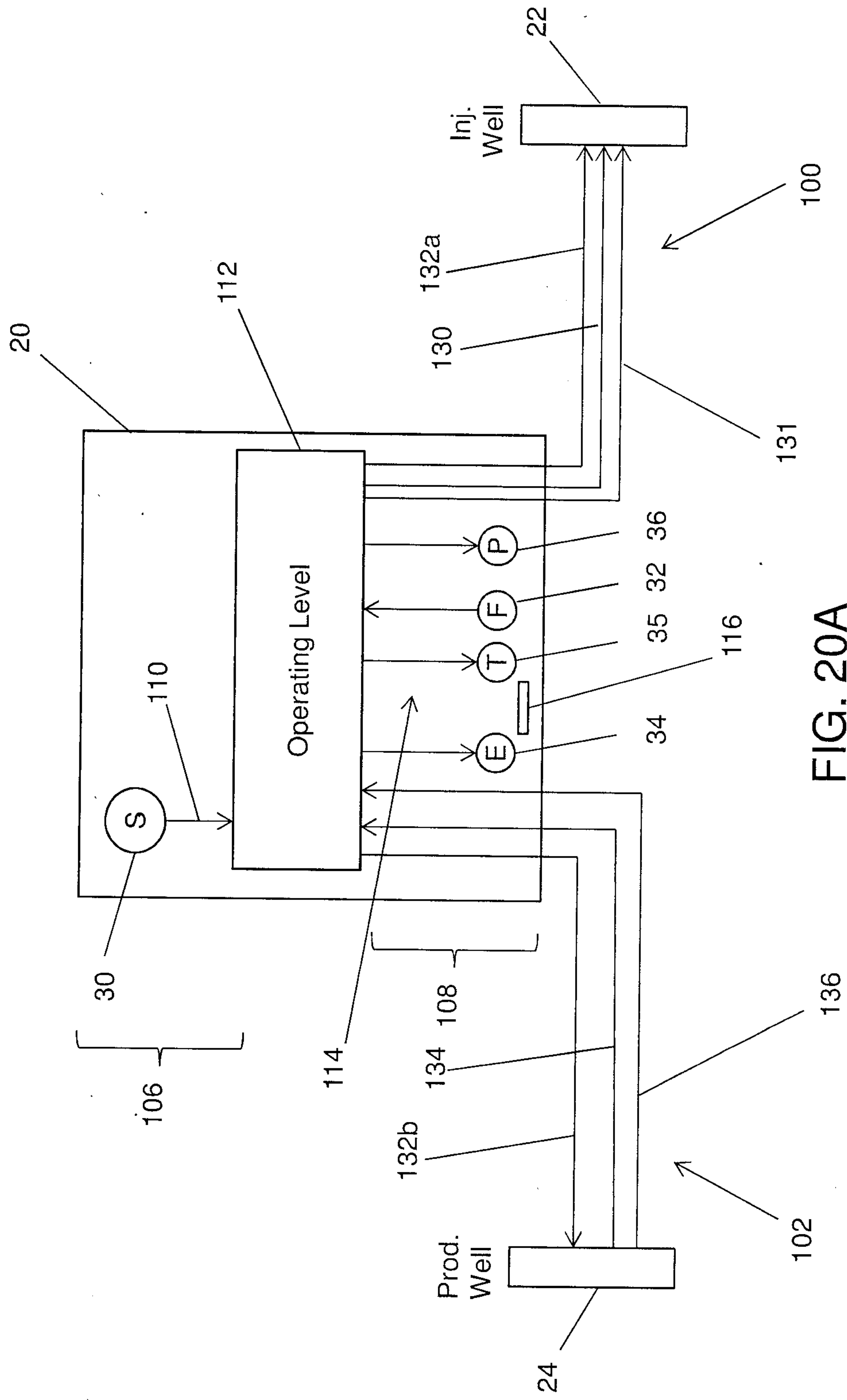


FIG. 20A

Well Pair Module – Start-up Phase

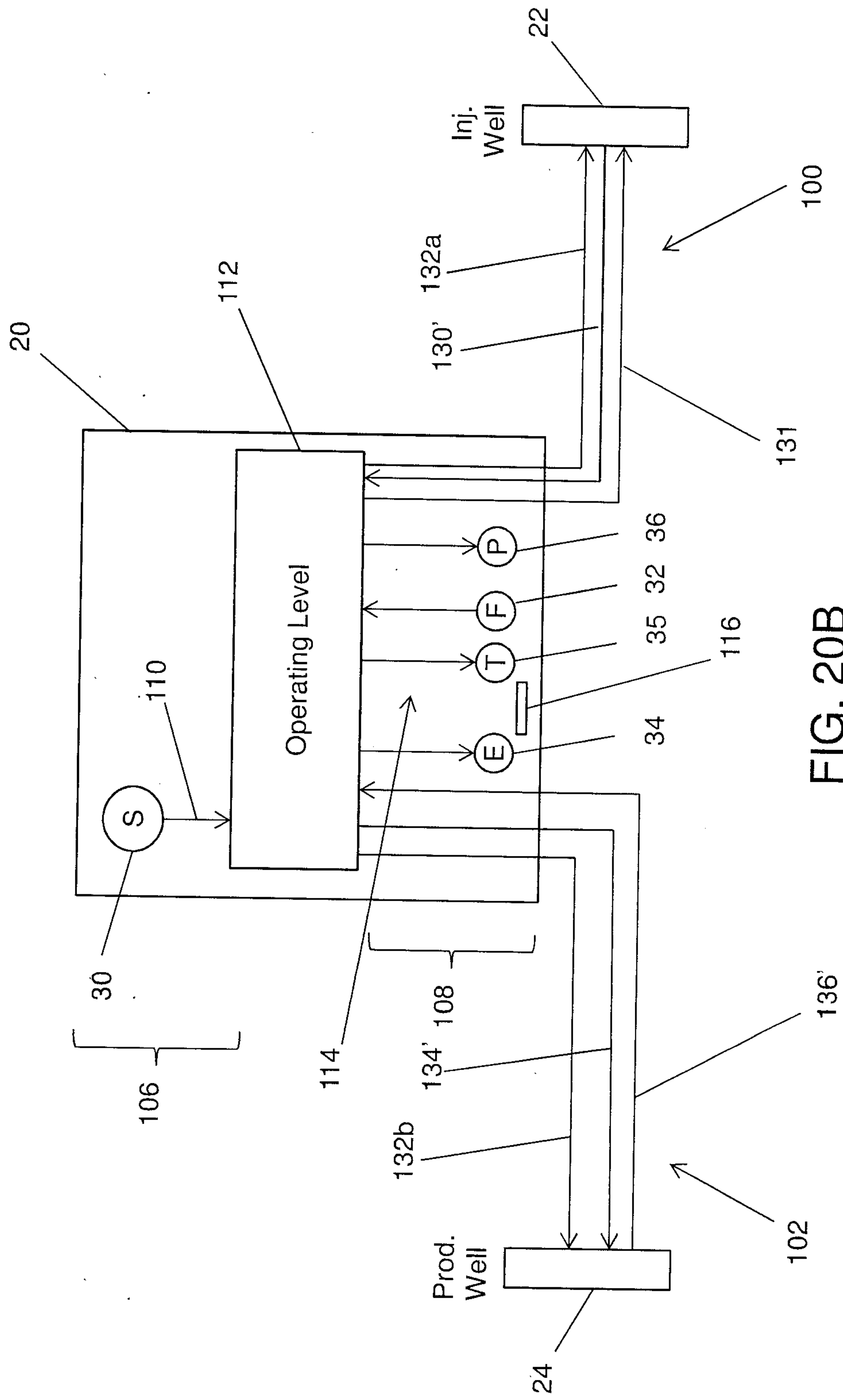


FIG. 20B

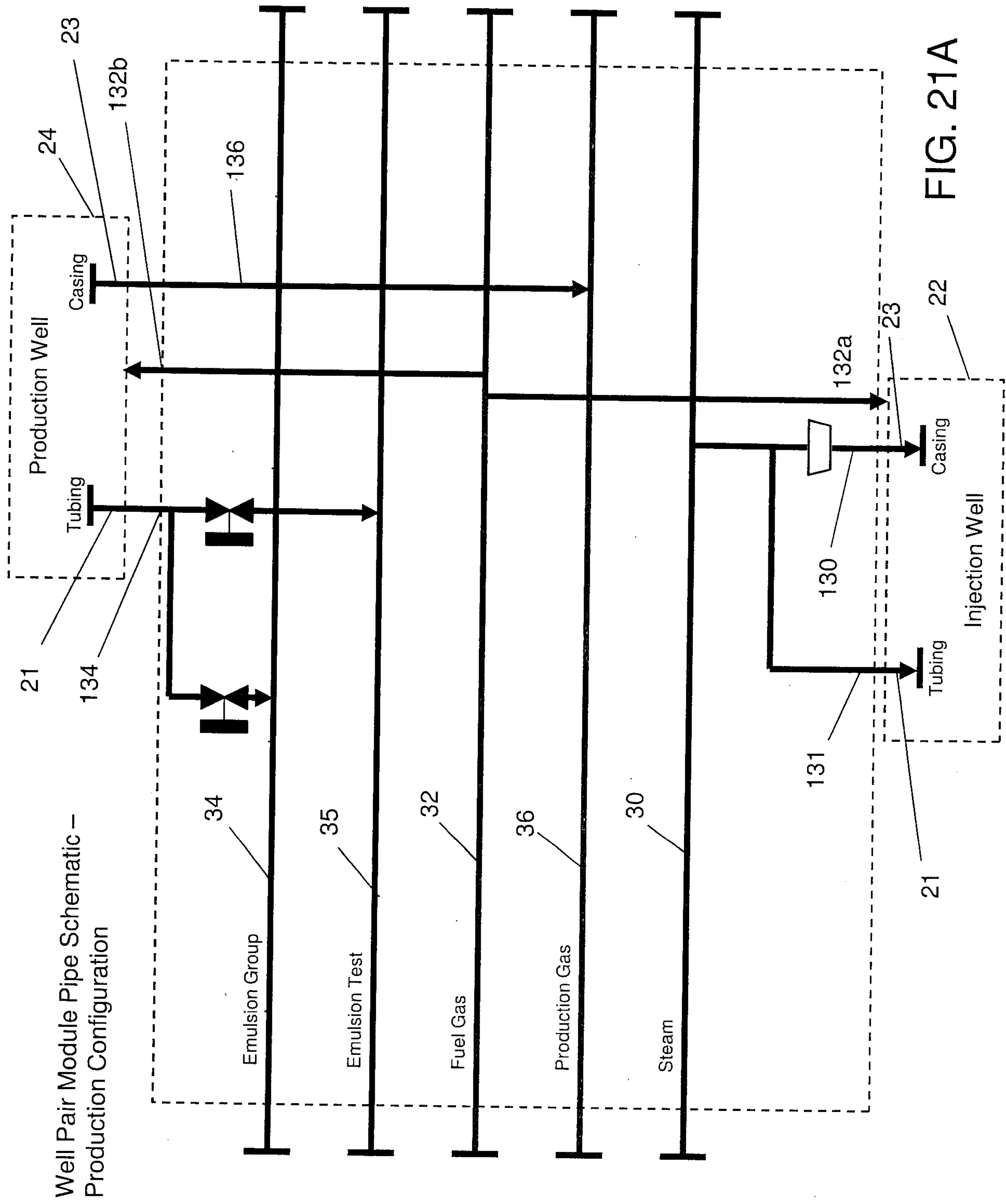


FIG. 21A

