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(54) **Method and system for carburizing or carbonitriding a component and correspondingly treated component**

(57) The invention relates to a method (100) for carburizing and/or carbonitriding a metallic component (1), wherein the metallic component (1) is exposed to carburizing or carbonitriding conditions, and wherein a carbon rich layer is formed on at least a part of the metallic component

(1) from a carbon or a hydrocarbon material prior to exposing the metallic component (1) to the carburization or carbonitriding conditions. Also included is a corresponding system for carburizing or carbonitriding and a correspondingly carburized or carbonitrided metallic component (1).

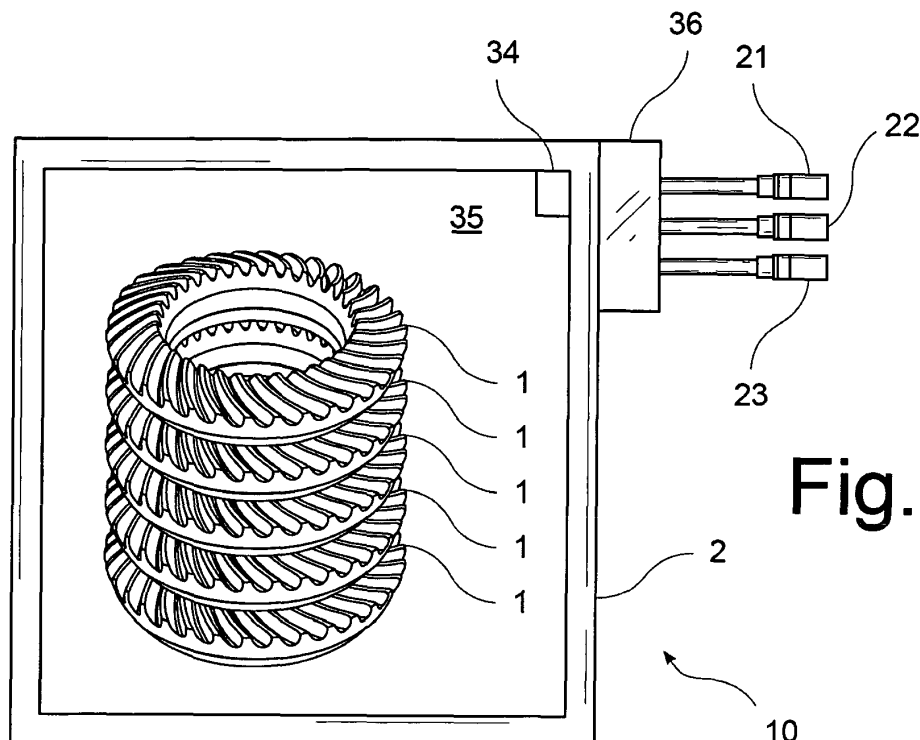


Fig. 1

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Description

[0001] The invention relates to a method and a system for carburizing or carbonitriding a metallic component and a correspondingly treated metallic component.

Prior art

[0002] The highest hardness of steel is obtained when its carbon content is high. Steel with high carbon content is hard, and thus wear resistant, but also brittle. It therefore cannot be used in components that are exposed to dynamic bending and tensile stresses. High carbon content, furthermore, impairs the machinability of steels.

[0003] This problem can be solved by using a low carbon content steel in machining a component to its final form and dimensions and then carburizing its surface, i.e. increasing its carbon content. After carburizing, the component comprises a hard case and a softer core. The case attains a hardness corresponding to its elevated carbon content while the core maintains its low carbon concentration and corresponding lower hardness. A similar effect is obtained by carbonitriding.

[0004] Methods of carburizing and carbonitriding are well known and reviewed in "Furnace Atmospheres No. 1 - Gas Carburizing and Carbonitriding", Linde Gas, 2007.

[0005] Carburizing and carbonitriding is typically performed as a heat treatment process carried out at a temperature where steel is austenitic, typically in a temperature range of 820 - 950 °C, and under a controlled furnace atmosphere at slight overpressure. Under such conditions, carbon or carbon and nitrogen is transferred from the atmosphere to the steel surface. The terms carburizing and carbonitriding are typically understood to include hardening, and thus quenching, as the final step. In this step, the carburized or carbonitrided case transforms to a martensite microstructure constituent. The term "case hardening" is sometimes alternatively used to more clearly describe the fact that the process includes the hardening step.

[0006] For practical realization of the above processes, ready-machined parts, for instance gears, are placed in a basket or mounted on a fixture. The basket or fixture is placed in a furnace containing a defined atmosphere and typically being held at the above mentioned temperatures. When the charge has reached its carburizing temperature, a transfer of carbon from the gas to the steel surface begins. Carburizing is allowed to proceed until the desired depth of penetration is reached. The charge is then moved from the heating chamber to a gas tight cooling chamber integrated into the furnace where it is rapidly quenched in an oil bath. After cooling, the charge undergoes washing, tempering and further treatment.

[0007] A number of different gas compositions for use in carburization or carbonitriding furnaces are known and details are omitted for conciseness. Briefly, the functions of the furnace atmosphere are to supply the necessary

carbon (and nitrogen), to provide the correct carbon (and nitrogen) content, to buffer from disturbances, to purge, to give uniform results, to maintain a positive pressure and to permit safety purging. Gas compositions typically used include carbon monoxide, methane and/or hydrogen, and typical carbon transfer reactions are e.g. given by the equations $2\text{CO} \rightarrow \text{C} + \text{CO}_2$ $\text{CH}_4 \rightarrow \text{C} + 2\text{H}_2$ and/or $\text{CO} + \text{H}_2 \rightarrow \text{C} + \text{H}_2\text{O}$.

[0008] A problem frequently observed in carburizing processes is internal oxidation. This process takes place during any heat treatment of a metal in an environment which contains oxygen or oxygen compounds if the metal has a certain solubility for oxygen, if the metal contains alloying elements with a higher affinity for oxygen than the parent metal, and if the diffusion rate of oxygen in the parent metal is higher than that of such alloying elements. Commercial steels fulfill these requirements. As mentioned, typical gas compositions used in carburization furnaces also include, at least bound, oxygen.

[0009] Depending on the degree of internal oxidation, so called "oxide arms" of considerable extent are formed by alloying elements such as chromium, manganese and silicon. These oxide arms impair the steel matrix by alloy depletion, resulting in so-called High Temperature Transformation Products (HTTP) and leading to decreased hardenability, and/or by inducing a brittle behavior due to the oxide arms acting as crack initiation sites. Internal oxidation is therefore detrimental as to fatigue strength, especially on dynamically loaded components. Historically, oxide layers were removed by heat treatment, machining or grinding. Post treatment steps, however, are costly and time consuming and should thus be avoided.

[0010] Consequently, there is still a need for solving the problem of internal oxidation during carburizing or carbonitriding processes.

Disclosure of the invention

[0011] This problem is solved by a method and a system for carburizing or carbonitriding a metallic component and by a correspondingly treated metallic component as defined in the independent claims. Preferred embodiments are subject of the corresponding subclaims and of the description that follows.

Advantages of the invention

[0012] While the following description primarily refers to "carburizing", it should be understood that the inventive concepts are advantageous in both carburizing and carbonitriding processes. Furthermore, special types of carburizing and carbonitriding processes, e.g. vacuum, plasma, pack and liquid drip feed carburizing, have been developed over the years and the invention may equally be advantageous in such special processes.

[0013] According to the invention, a carbon rich layer is formed on at least a part of a metallic component prior to exposing the metallic component to the carburizing or

carbonitriding conditions in a carburizing or carbonitriding furnace. The carbon rich layer is formed from carbon or from a suitable material as described below.

[0014] In other words, therefore, the invention suggests performing a pretreatment step before carburizing or carbonitriding. The pretreatment step involves forming a carbon rich layer on the metallic component which acts as an oxygen interceptor or scavenger and locally reduces oxygen content.

[0015] By forming a carbon rich layer, the extent to which oxides are formed during carburizing or carbonitriding is reduced significantly. The carbon rich layer forms a layer of locally higher reducing capacity in solid and/or gaseous form when exposed to the carburization or carbonitriding conditions as compared to the surrounding atmosphere, involving reactions such as $C + O_2 \rightarrow CO + 1/2 O_2$, $C + H_2O \rightarrow CO + H_2$ and/or $C + CO_2 \rightarrow 2 CO$. Therefore, internal oxidation is reduced. Consequently, oxides are formed to a lesser extent and with reduced depth.

[0016] According to the invention, two general advantageous ways are contemplated to form the carbon rich layer from the carbon or the hydrocarbon material.

[0017] A first general concept is to combust an understoichiometric mixture of the carbon or of the hydrocarbon material with air and/or oxygen and to deposit and/or apply the combustion products on the component to be carburized or carbonitrided.

[0018] Especially by providing a homogenous gas atmosphere from a hydrocarbon material and air and/or oxygen surrounding the corresponding metallic components and by igniting this homogenous gas atmosphere, a uniform and consistent formation of the carbon rich layer can be guaranteed.

[0019] This ignition is advantageously performed in an ignition chamber. As the ignition chamber, the carburizing or carbonitriding furnace or chamber may be used. Pretreatment, i.e. the formation of the carbon rich layer, carburizing or carbonitriding, and possible further treatment may thus be performed in a single chamber without the need for additional system components.

[0020] An alternative, yet advantageous method for depositing the carbon rich layer that involves combustion is performed by using a burner supplied with at least the carbon or the hydrocarbon material and air or oxygen. By using a burner, a targeted application of the carbon rich layer may be performed in specific parts or selected regions of the metallic components to be treated. By passing metallic components, e.g. via a conveyor, across the flame of a carbon or hydrocarbon material burner, a high throughput and high reproducibility can be obtained. Alternatively, application of the carbon rich layer can be performed using a hand held burner or a programmed robot.

[0021] A second general concept to apply a carbon or a carbon rich layer on a metallic component involves using a sprayer which is adapted for spraying the carbon or the hydrocarbon material onto at least a part of the

component. Spraying may involve spraying e.g. waxes, graphite, water/oil or water/oil/alcohol suspensions or gels as the carbon or the hydrocarbon material. Special care, however, needs to be taken to avoid evaporation of the carbon or the hydrocarbon material before the carburizing or carbonitriding temperatures are reached. Via spraying and by formation of a evaporation layer, a reducing gaseous atmosphere is obtained locally.

[0022] As a common advantage of the above inventive concepts, a lower amount of internal oxidation is obtained. Carburized or carbonitrided parts, therefore, need less post treatment, leading to significant savings in time and reduction of waste material. Metallic components treated according to the invention will show increased fatigue strength on carburized or carbonitrided parts. This will allow higher load on running components. Finished products, therefore, may be downsized, thus saving material. Lighter components, especially in vehicles, can serve in reducing fuel consumption and emission of exhaust gases. As compared to conventionally treated metallic components, carburizing or carbonitriding intensity and/or process time may be reduced, also leading to reduced energy and/or material consumption. The method according to the invention is especially suited to be retro fitted in existing furnaces or production lines.

[0023] Application of the carbon rich layer, be it via a burner or a sprayer, can be performed via a fixed burner installation, e.g. including a conveyor, by a robot, or manually. The carbon rich layer may be applied to individual metallic components or, with significant savings in time and material, to several components stacked or mounted to a support as previously mentioned.

[0024] A carbon or hydrocarbon material to be used according to the invention advantageously includes at least one component selected from the group consisting of acetylene, methane, ethane, propane, C4 to C14 linear and cyclic alkanes, alkenes, alcohols and aromatic hydrocarbons, natural gas, graphite powder, waxes, mineral oils, kerosene, and mixtures thereof.

[0025] Selection of the specific carbon or hydrocarbon material may depend on the mode of application, i.e. whether spraying or combustion is to be performed. Especially advantageous hydrocarbon materials for combustion are acetylene, propane or natural gas. As mentioned, advantageous hydrocarbon materials for spraying include waxes, graphite, water/oil, water/oil/alcohol suspensions or gels or kerosene.

[0026] An inventive carburization or carbonitriding method advantageously includes exposing the pretreated metallic components to carburizing or carbonitriding conditions including a temperature range of 820°C to 1080°C and a gas atmosphere containing at least carbon monoxide, methane and/or hydrogen. As mentioned, especially if the carbon rich layer is to be formed by combustion in an ignition chamber, this ignition chamber can be used as a carburizing or carbonitriding furnace for providing these conditions.

[0027] As to the inventive system, reference is made

to the above method features and advantages. A metallic component according to the invention is obtained or obtainable by a method or in a system as described above. Such a metallic component will typically comprise significantly lower oxygen contents and a significantly lower oxidation layer thickness. Typically, oxide arms in internal oxidation grow with about 1 micrometers per hour under conventional carburization or carbonitriding conditions, reaching, e.g. in automotive components, 7 to 14 micrometers depending on the specific process and furnace. A metallic component according to the invention will show significantly shorter oxide arms.

[0028] Further advantages and embodiments of the invention will become apparent from the description and the appended figures, in which

Figure 1 shows an arrangement for applying a carbon rich layer on metallic component according to a preferred embodiment of the invention,

Figure 2 shows a arrangement for applying a carbon rich layer on metallic component according to a preferred embodiment of the invention, and

Figure 3 shows a method for carburizing or carbonitriding a metallic component according to a preferred embodiment of the invention.

[0029] In the figures, like elements are indicated with identical reference numerals. Repeated explanation is omitted for conciseness.

[0030] Figure 1 shows an arrangement 10 for applying a carbon rich layer on a metallic component usable in a method for carburizing or carbonitriding metallic component.

[0031] The arrangement 10 includes an ignition and/or combustion chamber 2 which is adapted to be supplied with a combustible carbon or hydrocarbon material via a feed 21. The ignition and/or combustion chamber 2 comprises an interior space 35 which is dimensioned to accommodate a stack or pile of metallic components 1 to be treated according to the invention. The ignition and/or combustion chamber 2 is provided with a gas supply 36 comprising, besides the mentioned feed 21 for the combustible carbon or hydrocarbon material, gas tubes or feeds 22 and 23. Via feeds 22 and 23 air, oxygen or a combustible gas for providing a pilot or ignition flame can be supplied to the interior space 35 of the ignition and/or combustion chamber 2. Typical gas atmospheres provided within the ignition and/or combustion chamber 2 comprise, as mentioned, hydrocarbon materials, air and/or oxygen. For igniting the gas mixture, an ignition device 34 may be provided.

[0032] Figure 2 shows a further arrangement 20 for applying a carbon rich layer on metallic components 1 according to the invention. The arrangement 20 comprises a burner 3 with corresponding gas feeds 31 - 33. The

gas feeds 31 - 33 may be supplied via corresponding gas tubing with gases like those mentioned in relation to Figure 1. Typically, gas feeds 31 - 33 are provided to supply streams of a hydrocarbon material (feed 31), air and/or oxygen (feed 32) and combustible gases to provide a pilot flame (feed 33). Typically, understoichiometric gas mixtures are provided.

[0033] The burner 3 comprises a burner head 34 for providing a burner flame 35. Stacked and/or piled metallic components 1 may be moved below the burner 35 via a corresponding conveyer (not shown). The burner 3 is fixed to a burner mount 36 which may be attached to a holding structure and/or a robot. Alternatively, burner 3 may be embodied as a hand held burner 3.

[0034] Figure 3 schematically shows a method 100 according to the invention. Method 100 involves, at step 110, forming or applying a carbon rich layer on one or more metallic component(s), and, after application of the carbon rich layer, exposing 120 the metallic component(s) to carburization or carbonitriding conditions. After the exposition step 120, the metallic component(s) may be quenched and/or hardened 130.

Reference numerals

[0035]

10, 20 arrangement for applying a carbon rich layer

1 metallic component

2 ignition and/or combustion chamber

3 burner

21, 31 feed (carbon or hydrocarbon material)

22, 32 feed (air and/or oxygen)

23, 33 feed (pilot flame)

34 burner head

35 burner flame

36 burner mount

100 method for carburizing or carbonitriding

110 application of a carbon rich layer

120 exposition to carburizing or carbonitriding conditions

130 quenching, hardening

Claims

1. A method (100) of carburizing or carbonitriding a metallic component (1), wherein the metallic component is exposed (120) to carburizing or carbonitriding conditions, **characterized in that** a carbon rich layer is formed (110) on at least a part of the metallic component (1) from carbon or from a hydrocarbon material prior to exposing (120) the metallic component (1) to the carburization or carbonitriding conditions. 5
2. A method (100) according to claim 1, wherein the carbon rich layer is formed by deposition of combustion products generated by understoichiometric combustion of the carbon or the hydrocarbon material with air and/or oxygen. 10
3. A method (100) according to claim 2, wherein combustion is performed by igniting an understoichiometric mixture of the carbon or the hydrocarbon material and air and/or oxygen in an ignition chamber (2), especially in a carburizing or carbonitriding chamber. 15
4. A method (100) according to claim 2, wherein combustion is performed by using a burner (3) supplied with at least an understoichiometric mixture of the carbon or the hydrocarbon material and air and/or oxygen. 20
5. A method (100) according to claim 1, wherein the carbon rich layer is formed by spraying the carbon or hydrocarbon material onto at least a part or region of the metallic component (1). 25
6. A method (100) according to any one the preceding claims, wherein the carbon or hydrocarbon material includes at least one component selected from the group consisting of acetylene, methane, ethane, propane, C4 to C14 linear and cyclic alkanes, alkenes, alcohols and aromatic hydrocarbons, natural gas, graphite powder, waxes, mineral oils, kerosene, and mixtures thereof. 30
7. A method (100) according to any one the preceding claims, wherein the carbon or hydrocarbon material is provided as a solution, as a suspension and/or as a gel. 35
8. A method (100) according to any one the preceding claims, wherein the carburizing or carbonitriding conditions include a temperature range of 820 - 1080 °C and a gas atmosphere containing at least carbon monoxide, methane and/or hydrogen. 40
9. A system for carburizing or carbonitriding a metallic component (1), including means (10, 20) for forming a carbon rich layer on at least a part of the metallic component (1) from carbon or a hydrocarbon material according to any one of the preceding claims, and means (2) for exposing the metallic component (1) to carburization or carbonitriding conditions. 45
10. A system according to claim 9, wherein the means (10, 20) for forming the carbon rich layer include a combustion chamber (2), a burner (3) and/or a sprayer for carbon or a hydrocarbon material, and wherein the means (2) for exposing the metallic component (1) to the carburization or carbonitriding conditions include a carburization or carbonitriding furnace (2). 50
11. A metallic component (1) obtained or obtainable by a method according to any one of claims 1 to 8 and/or in a system according to claims 9 or 10. 55

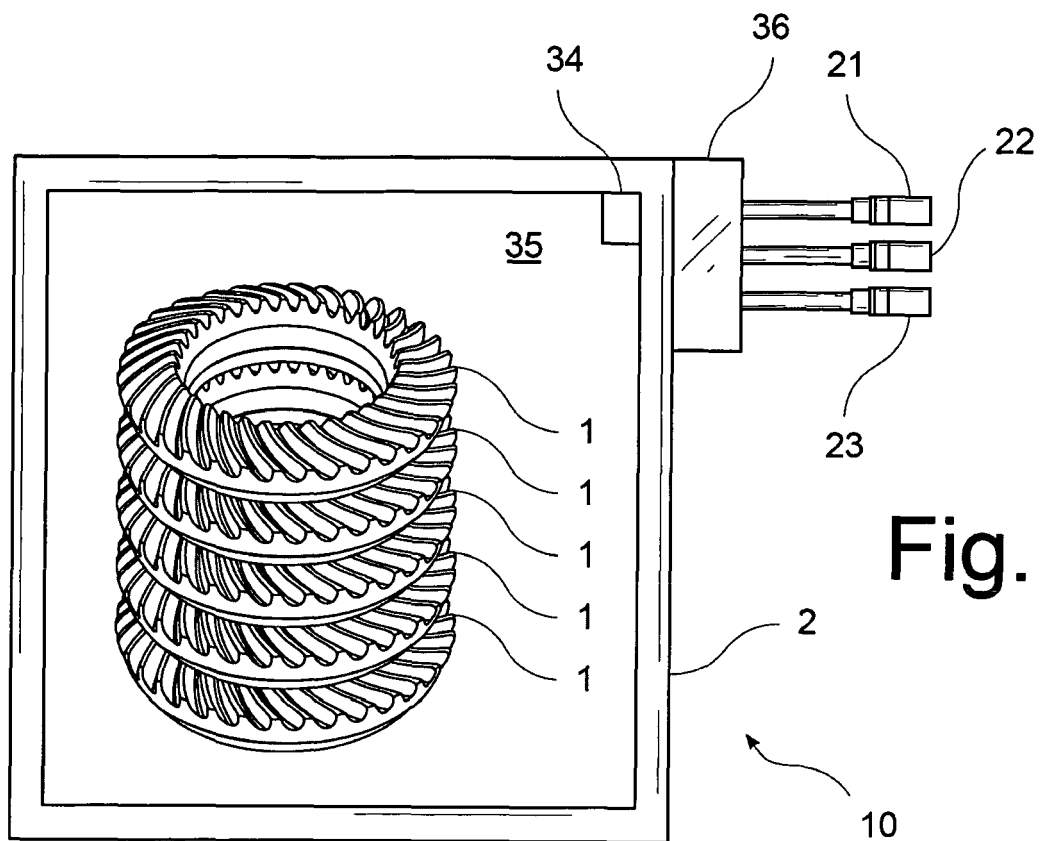


Fig. 1

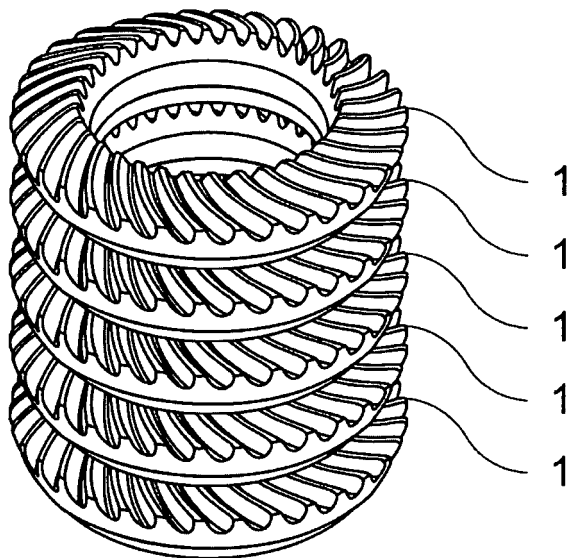
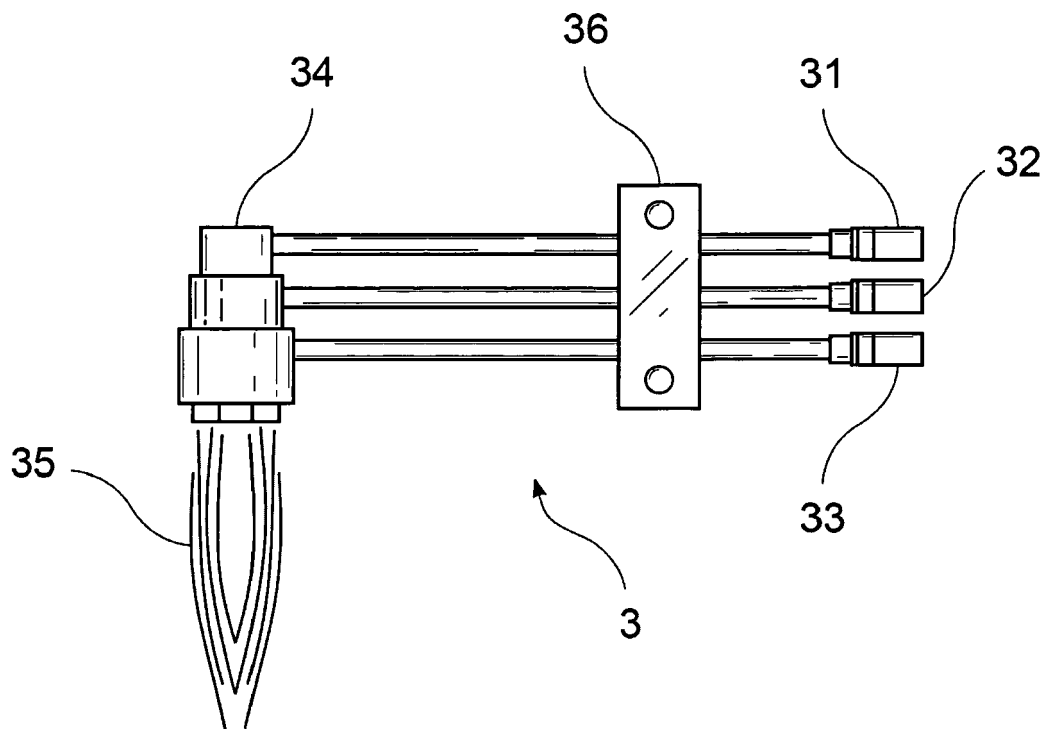
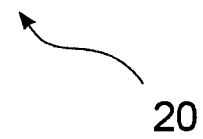


Fig. 2



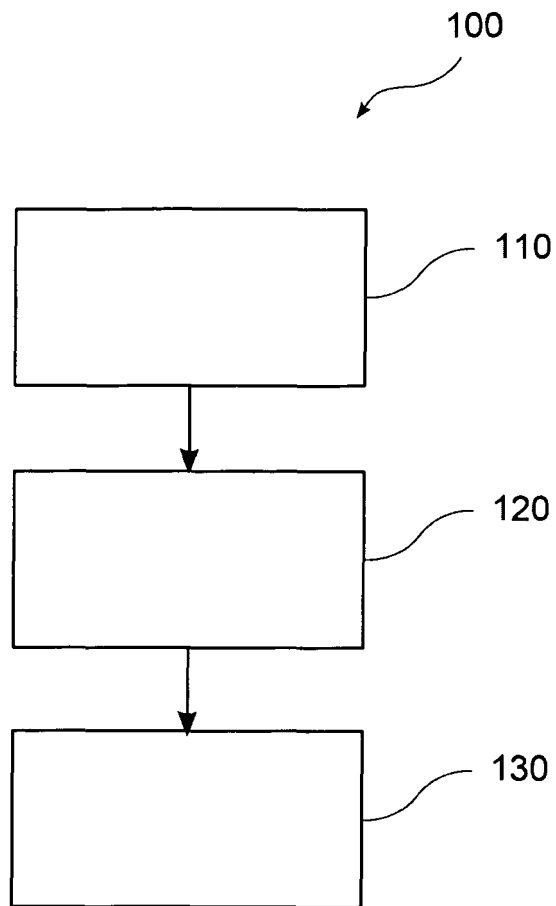


Fig. 3



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