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PROCESS FOR PRODUCING INERT GAS

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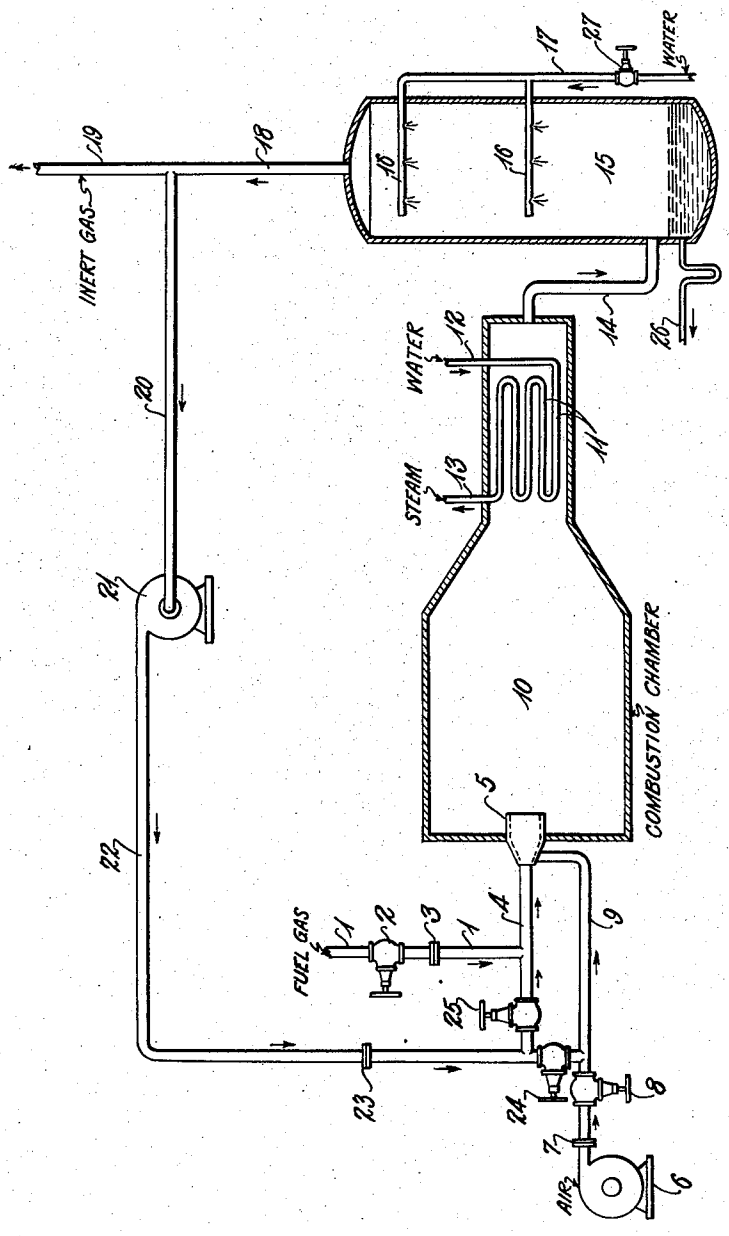

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PROCESS FOR PRODUCING INERT GAS

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6 Claims. (Cl. 23—5)

This invention relates to the manufacture of inert gas and particularly has reference to the production of an inert gas that is substantially free of acid impurities as well as impurities that may cause the formation of acid in the gas.

The invention is particularly useful for producing inert gas that must be subjected to high pressure under which the corrosive properties of gas become more apparent.

Many industries, and particularly the industry involving the production and distribution of natural gas for consumption as fuel gas, require the use of large volumes of inert gas. This inert gas must be chemically inactive and must be available readily in large quantities. Atmospheric air is unsuitable for use as inert gas in many instances due to the high concentration of active oxygen in the air. It is well-known that the active oxygen may largely be removed from the air by combustion of suitable fuel in the air. If the fuel is free from sulphur or sulphur compounds, an inert gas may be obtained by the combustion of the fuel in the air that is largely composed of nitrogen, water vapor, and carbon dioxide, which are relatively inactive gases. But the products of combustion will also contain small amounts of nitric oxide which may become an exceedingly active agent.

It is a primary object of the present invention to produce, by the combustion of a gaseous fuel in air, an inert gas that is substantially free of nitric oxide.

I have discovered that inert gases substantially free of nitric oxide may be prepared by the combustion of gaseous fuels in air if the raw fuel gas is intimately mixed with the proper amount of an inert gas prior to the combustion of the fuel gas with air. This discovery has made possible the production of an inert gas that is substantially free of nitric oxide and that may be used as an inert gas even under high pressures without causing trouble due to reactions of nitric oxide.

It is well-known that oxygen and nitrogen will combine to form nitric oxide at high temperatures. In fact, nitric oxide is produced from air in commercial practice by passing the air through a high temperature zone created by an electric arc. This reaction between nitrogen and oxygen will not proceed at low temperatures but will occur at flame temperatures resulting from the normal combustion of fuel gases with air. The flame temperature resulting from the combustion of fuel gas with air may be lowered considerably by mixing appreciable quantities of an inert gas, such as nitrogen, carbon dioxide, or steam, with either the fuel gas or air before combustion. According to my invention, a reduction in flame temperature, sufficient to substantially decrease the normal formation of nitric oxide during combustion, is accomplished by the addition of an inert gas to the fuel gas or air used for combustion. In the preferred operation, the inert gas thus added consists of a portion of the combustion gases produced in the process. It is probable that the decrease in the formation of nitric oxide is due partly to the decreased flame temperature and partly to the decreased concentration of oxygen in the combustion zone, as caused by the presence of the inert gas in the combustion zone. A flame temperature of from 2200° F. to 2800° F., obtained by adding the inert gas, is sufficiently low to preclude objectionable nitric oxide formation.

In the more detailed description of the process, reference will be made to the accompanying drawing in which the single figure is a sectional view of an apparatus suitable for practicing the invention. It is to be understood, however, that the invention is not limited to the specific apparatus chosen for illustration.

Referring more particularly to the drawing, the numeral 1 indicates a pipe that admits raw fuel gas through the flow control valve 2 and the meter 3 to the mixing pipe 4. In the preferred operation, a part of the inert gas produced by the process is removed from the pipe 18 through the pipe 20 by blower 21 and delivered through pipe 22, meter 23, and flow control valves 24 and 25, to the mixing pipes 4 and 9, where it mixes with the air and fuel gas entering the combustion zone. In the preferred practice of the invention, flow control valve 24 will remain closed so that all of the inert gas that is returned to the combustion zone will be mixed with the raw fuel gas entering the burner 5 through pipe 4. Air for combustion is supplied by blower 6 through meter 7, flow control valve 8, and pipe 9, to burner 5. Combustion of the gas occurs in combustion chamber 10. The hot products of combustion may be cooled by passing over boiler tubes 11 while generating steam. Water may be pumped into boiler tubes 11 through pipe 12, while the steam that is generated is allowed to leave the boiler tubes through pipe 13. The partially cooled products of combustion pass through pipe 14 to cooler 15, where they are cooled by contact with water entering through flow control valve 27, pipe 17, and spray heads 16. The warm water leaves the cooler 15

through pipe 26. The cooled products of combustion are returned in part to the combustion zone through pipe 28, as previously described, while the balance of the inert gas leaves through pipe 19 to enter a blower or compressor, not shown on the drawing, to be compressed to any desired pressure.

The precise amount of inert gas that should be returned to the burner is dependent on several factors, such as the temperature of the gas mixture entering the burner, the chemical nature of the raw fuel gas, and the concentration of nitric oxide that is permissible in the inert gas that is produced. The higher the temperature of the inert gas, the greater must be the amount thereof returned to the burner to produce the same reduction in the nitric oxide concentration. Fuel gases of high thermal value will require the return of more inert gas to the burners than fuel gases of low thermal value. It has been found that if the inert gas is cooled to approximately atmospheric temperature before return thereof to the burners, sufficient inert gas should be admixed with the raw fuel gas to reduce the thermal value of the mixed gas entering the burners to 100 to 400 British thermal units per cubic foot or gas. Thus, if natural gas having a thermal value of 1000 British thermal units per cubic foot of gas is to be burned with air to produce inert gas, each volume of natural gas should be mixed, prior to combustion thereof, with from two and one-half to nine volumes of inert gas to produce an inert gas containing a negligible concentration of nitric oxide. However, the nitric oxide content of the inert gas produced by the combustion of natural gas may be very materially reduced from its normal value by returning even one or two volumes of inert gas to be mixed with the raw fuel gas prior to combustion, and ordinarily it will not be necessary to add more than ten volumes of inert gas per volume of natural gas.

The inert gas, instead of being introduced to the fuel gas supply line, may be mixed with the fuel gas by introduction to the air supplied for combustion. However, it is essential that the inert gas be mixed with either the air for combustion or with the fuel gas, or both, before combustion of the fuel gas with the air, to produce the desired results.

It is well-known that nitric oxide will react with water and free oxygen to form nitric acid. This reaction is extremely slow under high temperatures and low pressure but becomes rapid under high pressures and low temperatures. In fact, it has been found that if inert gas obtained from the normal combustion of natural gas in air is compressed to 15 or 20 atmospheres and cooled to atmospheric temperatures, sufficient nitric acid will be formed in the gas to cause rapid corrosion and deterioration of the iron and steel equipment used to confine the gas. But if the combustion of the natural gas is carried out according to the process of this invention, the concentration of nitric oxide in the inert gas is reduced to such a degree that corrosion of the iron and steel equipment by nitric acid becomes so slight as to be negligible. Inert gas, produced by the normal combustion of natural gas in air, has been found to show a concentration of nitric oxide of from 30 to 100 volumes of nitric oxide per million volumes of inert gas. Inert gas produced in accordance with my invention will show a concentration of nitric oxide of approximately one or two volumes of nitric oxide per million volumes of inert gas.

By the term "inert gas" as employed in the claims, is meant a non-combustible gas which will not attack the iron of gas mains when maintained therein at temperatures within the range of atmospheric temperatures at a relatively high pressure, that is, a gas which will not support combustion with oxygen, which contains very little if any free oxygen, and which contains insufficient nitric acid or nitrogen oxides capable of forming nitric acid to cause corrosion and consequent failure of the mains.

From the foregoing, it will be seen that I have devised a simple and practical process for producing inert gas substantially free of acidic and acid-forming impurities, and although I have described the invention with considerable particularity, it is to be understood that various changes and modifications may be made in the specific operations herein chosen for illustration without departing from the spirit and scope of the invention as defined in the appended claims.

Having described my invention, I claim:

1. The method of producing inert gas substantially free from nitrogen oxides from a combustible gas substantially free from nitrogen oxides and having a thermal value of approximately 1000 B. t. u. per cubic foot, which comprises burning said combustible gas in admixture with sufficient air to provide substantially complete combustion and sufficient products of combustion substantially free from nitrogen oxides to maintain the temperature of combustion below approximately 2800° F.

2. The method of producing inert gas substantially free from nitrogen oxides from fuel gas substantially free from nitrogen oxides and normally burning at temperatures in excess of 2800° F., which comprises burning said fuel gas in the presence of sufficient air to provide substantially complete combustion and sufficient products of combustion substantially free from nitrogen oxides to maintain the temperature of combustion below approximately 2800° F.

3. The method of producing inert gas substantially free from nitrogen oxides from fuel gas substantially free from nitrogen oxides and having a thermal value in excess of 400 B. t. u. per cubic foot, which comprises burning said fuel gas in admixture with sufficient air to provide substantially complete combustion and products of combustion substantially free from nitrogen oxides in sufficient quantity to maintain the temperature of combustion below approximately 2800° F., and utilizing a portion of the products of said burning as said products of combustion.

4. The process of producing an inert gas under high pressure and substantially free from nitrogen oxides from combustible gas substantially free from nitrogen oxides and having high thermal values, which comprises burning at substantially atmospheric pressure a mixture including said combustible gas and sufficient air to provide substantially complete combustion, returning products of combustion from said burning and adding the same in sufficient amounts to said mixture to maintain the temperature of burning below approximately 2800° F., and compressing the remaining products of combustion.

5. The process of producing an inert gas having a negligible concentration of nitric acid which comprises burning a mixture of gases substantially free from nitrogen oxides, said mixture

including a combustible gas, sufficient air to provide substantially complete combustion, and an inert gas diluent in an amount sufficient to prevent the temperature of combustion increasing above that at which approximately two volumes of nitric oxide are formed per million volumes of inert gas.

6. The method of producing inert gas containing a concentration of oxides of nitrogen of the order of two parts per million by gas volume from a combustible gas substantially free from nitrogen compounds and having a thermal value of the order of one thousand B. t. u. per cubic foot, which comprises burning said combustible gas in admixture with sufficient air for substantially complete combustion and in admixture with a volume of products of combustion substantially free from nitrogen oxides said volume of products of combustion being equal to two and one-half to ten times the volume of the combustible gas.

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