

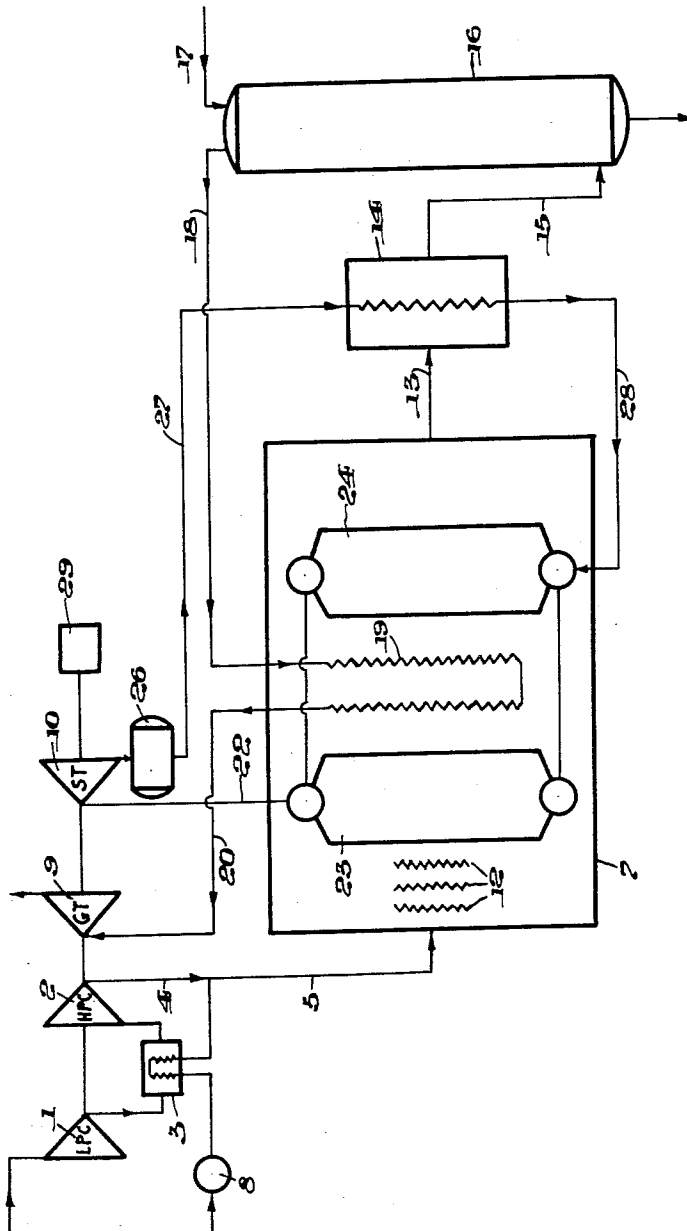
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ACID PRODUCING PLANT

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ACID PRODUCING PLANT

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This invention relates to the manufacture of acid, and more particularly to an improved plant or apparatus for making a gaseous oxide that can be absorbed in water to make the acid.

For example, the manufacture of nitric acid from ammonia involves the catalytic oxidation of ammonia on a platinum catalyst, as is well known. The nitric oxide that is produced is absorbed in water to produce nitric acid. The rate of reaction and the final concentration of nitric acid are increased materially by increasing the reaction pressure levels. Accordingly, the practice has been to deliver a mixture of vaporized ammonia and compressed air to a reaction chamber where a platinum catalyst causes the mixture to burn. This produces NO, some of which becomes NO₂ as it is cooled after leaving the reaction chamber. The gas is delivered to an absorption tower where the nitric oxide is absorbed in water to produce nitric acid. The top of the tower has an outlet for the escape of excess nitrogen. It has been proposed to add heat to this nitrogen in a combustion chamber so that it can be used to operate a gas turbine that helps to drive the air compressor, but in addition to the cost of operating the combustion chamber, the power thus recovered is still insufficient to make the compressor self-sustaining. This is due to the loss in gas weight flow by absorption of the nitric oxide and condensation of water produced during combustion. It also has been proposed, therefore, to add a steam turbine that is operated by steam produced in a waste heat boiler heated by exhaust gas from the gas turbine. The disadvantage of such a system is that it requires a considerable amount of fuel to heat the nitrogen in the combustion chamber high enough to operate the gas turbine efficiently and to produce steam in the waste heat boiler.

It is among the objects of this invention to provide an acid plant in which the air compressor is self-sustaining, without requiring either a combustion chamber to heat the tail gas from the absorption tower or some other means of supplying power not generated by the heat of the chemical reaction.

In accordance with this invention an air compressor is driven by a gas turbine and a steam turbine. The substance that is used in the plant for producing the necessary gaseous oxide is first vaporized or gasified, if it is not already in that form, and mixed with compressed air and then oxidized in a combustion chamber. Some of the heat of combustion is used for generating steam in a boiler connected with the inlet of the steam turbine. The outlet of the turbine is connected with a condenser which in turn is connected by an economizer with the boiler. Gaseous oxide from the oxidation reaction is conducted through the economizer, where it is cooled, and then to an absorption tower. Water is delivered to the tower to absorb the oxide and produce acid, which can be drained from the tower. The top of the tower is provided with an outlet for a tail gas and is connected with a heat exchanger that leads to the inlet of the gas turbine. The heat exchanger also is exposed to the heat of combustion

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in order to raise the temperature of the tail gas to the desired point before it reaches the gas turbine. The power produced in this way by the two turbines together is sufficient to drive the compressor.

5 The preferred embodiment of the invention is illustrated in the accompanying drawing, which is a diagrammatic view of my acid making plant.

Referring to the drawings, a low-pressure compressor 1 and a high-pressure compressor 2, or equivalent low and high-pressure stages of a single compressor, are connected through the cooling side of an intercooler. Where the substance to be oxidized must first be vaporized, this unit may be a combination intercooler and vaporizer 3. The outlet of the high-pressure compressor is connected by a conduit 4 with another conduit 5 leading from the vaporizing side of the vaporizer-intercooler to the inlet of a reaction or combustion chamber inside a pressure casing 7. A liquid substance to be converted into a gaseous oxide in this plant, such as ammonia, is delivered by a pump 8 to the vaporizer-intercooler, where it is vaporized by the heat extracted by it from the compressed air, which is thereby cooled. The compressors are driven by gas turbine 9 and a steam turbine 10.

As the mixture of vapor and compressed air enters one end of the combustion chamber, it burns and produces considerable heat. This oxidation reaction also produces the gaseous oxide that is absorbed by water later in the plant, to form an acid. In making nitric acid, vaporized ammonia is oxidized with the compressed air as the mixture of air and vapor pass over a platinum catalyst 12, generally in the form of fine gauze, in the combustion chamber. The reaction produces NO and NO₂, the NO₂ being formed principally as the gas is cooled. The gas leaves the other end of the chamber through a conduit 13 and then flows through an economizer 14 and another conduit 15 and into the lower part of an absorption tower 16, to the top of which water is delivered through a pipe 17 in order to form nitric acid that can be drained out of the bottom of the tower.

40 The nitrogen tail gas from the tower escapes through an outlet in its upper end and flows through a conduit 18 to a heat exchanger 19 located in combustion chamber casing 7. The outlet of the exchanger is connected by a conduit 20 with the inlet of the gas turbine. It will be seen that the heat generated in the chamber by the burning of the air and ammonia vapor mixture will heat the gas in the heat exchanger.

The power obtained from the gas turbine is not sufficient to drive the compressors. It is necessary to add to it the power of the steam turbine 10. The steam for this turbine is produced by a boiler located in the reaction chamber and connected by a steam pipe 22 with the turbine inlet. The boiler heat transfer surfaces absorb heat released by combustion over catalyst 12 and protect the pressure casing 7 of the combustion chamber against excessive temperatures. The boiler has primary and secondary evaporators 23 and 24, respectively, that most suitably are so arranged that the hot gaseous oxide flowing through the chamber will first heat the primary evaporator, then the heat exchanger 19 and finally the secondary evaporator. With this arrangement, wherein primary evaporator 23 controls the gas temperatures to heat exchanger 19, the nitrogen gas in the heat exchanger will not be overheated, and yet will be heated to a high enough temperature, preferably, about 1000° F. to 1100° F., for efficient operation of the gas turbine. The secondary evaporator then further reduces the temperature of the gaseous oxide to a value where it can be brought down to about 250° F. by the economizer 14. As members 12, 23, 19 and 24 are all in a single pressure casing 7, instead of in separate units piped together, the boiler and heat

exchanger can recover as much heat as desired from catalyst 12.

The outlet of the steam turbine leads to a condenser 26 which is connected by a pipe 27 to the economizer. In the economizer the water is heated by heat extracted from the gas from the combustion chamber. The hot water outlet of the economizer is connected by a pipe 28 to the secondary evaporator 24.

The steam produced by the boiler drives the steam turbine to produce enough power in conjunction with the gas turbine to operate the compressors. In most cases, there will be a surplus of power which can be used for driving an electric generator 29 connected with the turbines. Also, in some instances it may be desirable to add a waste heat boiler or a superheater for evaporator 23 to recover additional heat from the gas turbine exhaust gases.

Other acids may be made in this same general way from such substances as sulfur, phosphorous, methane and the like which can be converted into gaseous oxides in this plant.

According to the provisions of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. A plant for making acid by absorbing in water a gaseous oxide productive of said acid and produced by oxidation of a substance productive of said oxide with compressed air, said plant comprising an air compressor, a gas turbine and a steam turbine for driving the compressor, a combustion chamber for producing said oxidation, a conduit connecting the outlet of the compressor with said chamber, a boiler having primary and secondary evaporators connected with the inlet of the steam turbine and heated by the heat of said combustion, a condenser connected with the steam turbine outlet, an economizer connecting the condenser with the boiler, an absorption tower, means for conducting said gaseous oxide through the economizer to said tower, means for delivering water to the tower to absorb said oxide and produce said acid therein, the top of the tower being provided with a tail gas outlet, and a heat exchanger connecting said tower outlet with the inlet of the gas turbine, the exchanger being exposed to said heat of combustion between the evaporators for raising the temperature of the tail gas before it reaches the gas turbine.

2. A plant for making acid by absorbing in water a

gaseous oxide productive of said acid and produced by oxidation of a substance productive of said oxide with compressed air, said plant comprising high and low pressure compressors for air, a gas turbine and a steam turbine for driving the compressors, a vaporizer-intercooler between the compressors, means for conducting said substance in liquid phase to the vaporizer-intercooler to vaporize it as it cools the partially compressed air, means for mixing said vapor and compressed air from the high pressure compressor, a combustion chamber for burning said mixture to produce said gaseous oxide, a conduit delivering said mixture to said chamber, a boiler having primary and secondary evaporators connected with the inlet of the steam turbine and heated by the heat of said combustion, a condenser connected with the steam turbine outlet, an economizer connecting the condenser with the boiler, an absorption tower, means for conducting said gaseous oxide through the economizer to said tower, means for delivering water to the tower to absorb said oxide and produce said acid therein, the top of the tower being provided with a tail gas outlet, and a heat exchanger connecting said tower outlet with the inlet of the gas turbine, the exchanger being exposed to said heat of combustion between the evaporators for raising the temperature of the tail gas before it reaches the gas turbine.

3. A plant for making acid by absorbing in water a gaseous oxide productive of said acid and produced by oxidation of a substance productive of said oxide with compressed air, said plant comprising an air compressor, a gas turbine and a steam turbine for driving the compressor, a casing containing a combustion chamber for producing said oxidation, a conduit connecting the outlet of the compressor with said casing, a boiler in said combustion chamber casing having primary and secondary evaporators connected with the inlet of the steam turbine, a condenser connected with the steam turbine outlet, an economizer connecting the condenser with the boiler, an absorption tower, means for conducting said gaseous oxide through the economizer to said tower, means for delivering water to the tower to absorb said oxide and produce said acid therein, the top of the tower being provided with a tail gas outlet, and a heat exchanger in said combustion chamber casing between the evaporators and connecting said tower outlet with the inlet of the gas turbine, the exchanger being adapted to raise the temperature of the tail gas before it reaches the gas turbine.

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