

F. HÄUSSER.
PROCESS OF MAKING NITRIC ACID.
APPLICATION FILED MAY 31, 1906.

961,350.

Patented June 14, 1910.

FIG. 1.

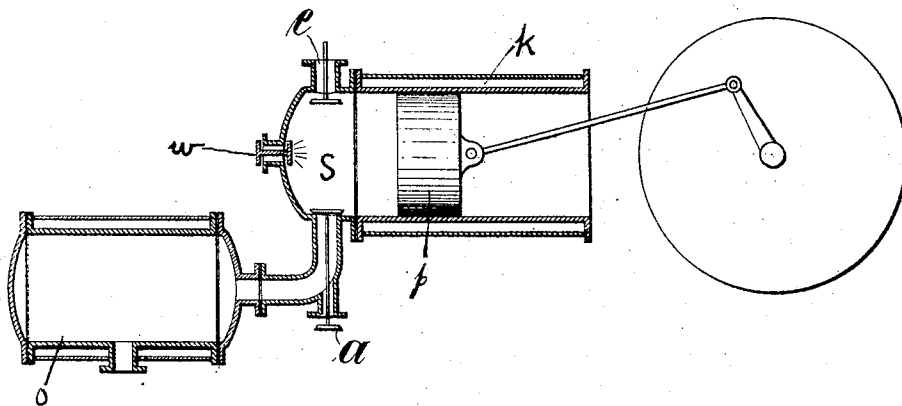
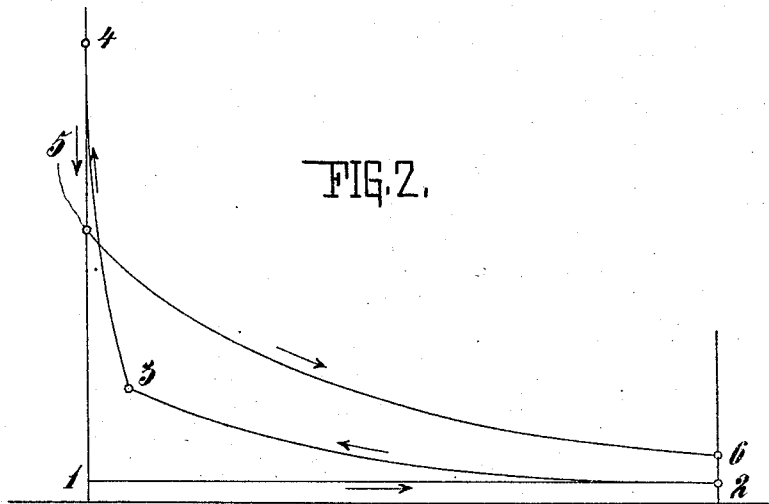


FIG. 2.



Witnesses
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PROCESS OF MAKING NITRIC ACID.

961,350.

Specification of Letters Patent. Patented June 14, 1910.

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To all whom it may concern:

Be it known that I, FRIEDRICH HÄUSSER, a subject of the King of Bavaria, residing at Kaiserslautern, in the Kingdom of Bavaria and German Empire, have invented certain new and useful Improvements in the Production of Oxids of Nitrogen, of which the following is a specification.

It is known that at high temperatures nitrogen and oxygen combine directly with each other so as to form oxid of nitrogen which at ordinary temperature further combines with oxygen so as to form dioxid of nitrogen, which will produce nitric acid when dissolved in hot water. This method of producing nitric acid has been carried out on a commercial scale in North America, especially at the Niagara Falls where the oxidation of the nitrogen has been effected by means of the electric arc. It is, however, very inconvenient and expensive to produce in this manner the high temperatures required for manufacturing nitric acid and it has been found that in order to obviate said inconveniences the oxidation of nitrogen can be effected in a more economical way by means of explosive combustion that is to say by heating or burning a mixture of nitrogen gas and oxygen gas for instance in an explosive engine, together with a suitable fuel, as coal-gas, benzene-vapor or the like, and preferably after the said gas mixture has been compressed, prior to ignition, adiabatically, as far as possible, as the gain in oxid of nitrogen very quickly increases in proportion to the rise of temperature. The formation of oxid of nitrogen being a reversible reaction it is necessary, in order to avoid any decomposition of the oxids of nitrogen formed, to suddenly chill the gas mixture at the moment of maximum temperature. Evidently the gas mixture must be cooled down to a degree where the reaction speed is so low that a decomposition of the oxid of nitrogen practically cannot take place, that is to say, to 1600° C or lower. But as the gas mixture still exerts a high pressure at this temperature, it is profitable to allow the gas mixture to expand, after having been cooled, in a well known manner.

A machine for carrying out the new method is shown in the annexed drawing, wherein—

Figure 1 is a diagrammatical sectional view of an explosion engine and Fig. 2 is an ideal indicator diagram of the same.

In Fig. 1, K indicates the cylinder of an internal combustion engine, which may be a four-cycle engine. *p* is the piston arranged in said cylinder, *e* the admission valve for admitting the combustible gas-mixture into the cylinder, *s* is the combustion-chamber, *a* the exhaust valve, *w* the valve for admitting the liquid to chill the explosive mixture and O a cooled receptacle.

Fig. 2 shows in a theoretical diagram the various pressures which occur in the cylinder K during the operation of the engine.

When piston *p* starts to the right in Fig. 1, combustible gas mixture is drawn into the cylinder K through the valve *e*, which is indicated by the line 1—2 in Fig. 2. On the return movement of the piston toward the left in Fig. 1, the mixture is compressed adiabatically, which is indicated by the line 2—3 in Fig. 2. The pressure of the mixture gradually increases from 2 to 3. At the point 3, a little before piston *p* has reached its inner dead point, the mixture is ignited, and its pressure and temperature quickly rise, as indicated by the line 3—4 in Fig. 2, during which time the piston reaches its inner dead point. At this position of the piston *p*, the mixture is suddenly chilled by injecting cold water or the like through the valve *w* at the left hand end of the cylinder K, whereby a decomposition of the oxid of nitrogen previously formed is prevented, while the pressure and temperature fall, as indicated by the line 4—5 in Fig. 2. The mixture then, expands and drives the piston *p* to the right in Fig. 1, which is indicated by the line 5—6 in Fig. 2, the pressure gradually decreasing. At the point 6 the piston starts back to force out the burned gases through the valve *a* into the cooled receptacle O, which is indicated by the line 2—1 in Fig. 2, after which the cycle just described is repeated. In the cooled receptacle O the oxid of nitrogen contained in the gas mixture is allowed to further oxidize and dissolve to form nitric acid.

The method is not altered in its features if in lieu of a four-cycle engine an explosion motor of any other type, say a two cycle engine, is employed for the purpose.

The gain in oxid of nitrogen depends on both the explosion temperature and the proportion of nitrogen and free oxygen in the gases resulting from the explosion, that is exhaust gases. The best results are obtained in this regard if there is equality. The

gain, therefore, can be increased by adding oxygen to the air used for the explosive mixture.

The most favorable proportion of oxygen and free nitrogen producing the greatest amount of nitric acid exists, if the mixture after the explosion contains the same amount of oxygen and nitrogen. This result may be obtained by adding artificial oxygen to the atmospheric air. The simplest way is, however, to use ordinary atmospheric air, in which case 100 parts of the initial fresh gas mixture contains about 68 parts nitrogen, 18 parts oxygen and 14 parts hydrocarbon vapors in the form of lighting gas. The composition of the mixture varies with the quality of the lighting gas. If the quality is good, less gas is added, and vice versa. The mixture having the proportions above stated, is a gas having a heating value of 5,000 calories.

The temperature, which is indicated by the point 4 in Fig. 2 should be as high as possible, because the production of nitric acid increases very much with the increasing temperature. The temperature should be preferably no less than 1900 to 2,000° C. Such temperatures can be easily obtained by a sufficiently high compression of the combustible mixture prior to its ignition and by the use of gases of great heating quality, as for instance lighting gas mixed with air. It should be mentioned, however, that it is impossible to state with any surety the explosive temperature of a mixture of air and a combustible gas in advance.

What I claim as my invention, and desire to secure by Letters Patent, is:—

1. Process of making nitric acid, which consists in first forming gaseous oxids of nitrogen by the explosive combustion of a

combustible gas mixture, composed of oxygen, nitrogen and a combustible agent, carrying the temperature produced by the explosion to as high a degree as possible and maintaining it constant as long as is necessary for the formation of oxids of nitrogen, then suddenly chilling the gaseous products of combustion to a degree sufficient to prevent the oxids of nitrogen formed by the combustion from decomposing, and allowing the thus chilled gaseous products of combustion to expand for the purpose of utilizing the potential energy stored therein and thereafter further cooling the gaseous products to condense the nitric acid.

2. The process of making nitric acid, which consists in first forming gaseous oxids of nitrogen by the explosive combustion of a combustible gas mixture composed of oxygen, nitrogen and a combustible agent, carrying the temperature produced by the explosion as high as possible, and maintaining it constant as long as is necessary for the formation of oxids of nitrogen, then suddenly chilling the gaseous products of combustion to a degree sufficient to prevent the oxids of nitrogen formed by the combustion from decomposing, allowing the thus chilled gaseous products of combustion to expand for the purpose of utilizing the potential energy stored therein and finally exhausting the gaseous products of combustion into a cooled receptacle to permit the oxids of nitrogen to further oxidize and condense to form nitric acid.

In testimony whereof I have affixed my signature in presence of two witnesses.

FRIEDRICH HÄUSSER.

Witnesses:

FRIEDRICH WEGNER,
CARL GARZ.