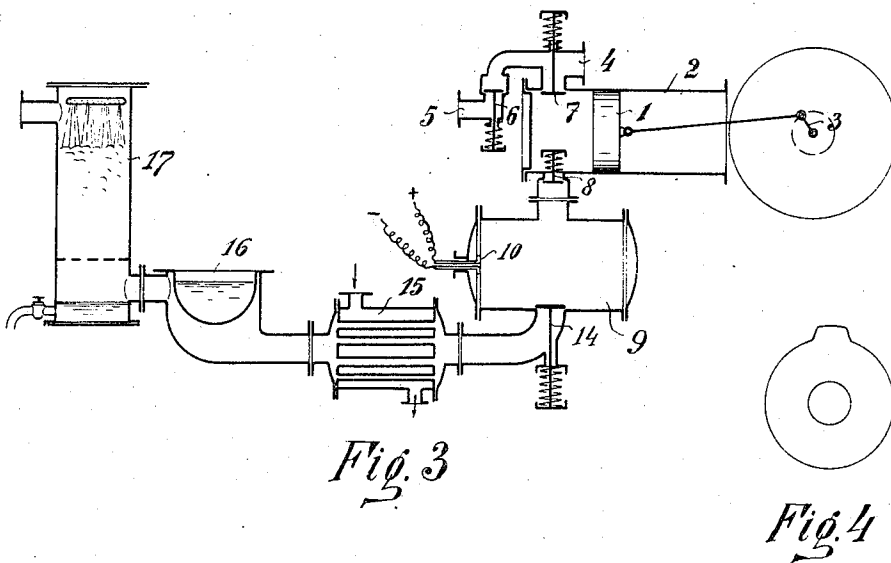
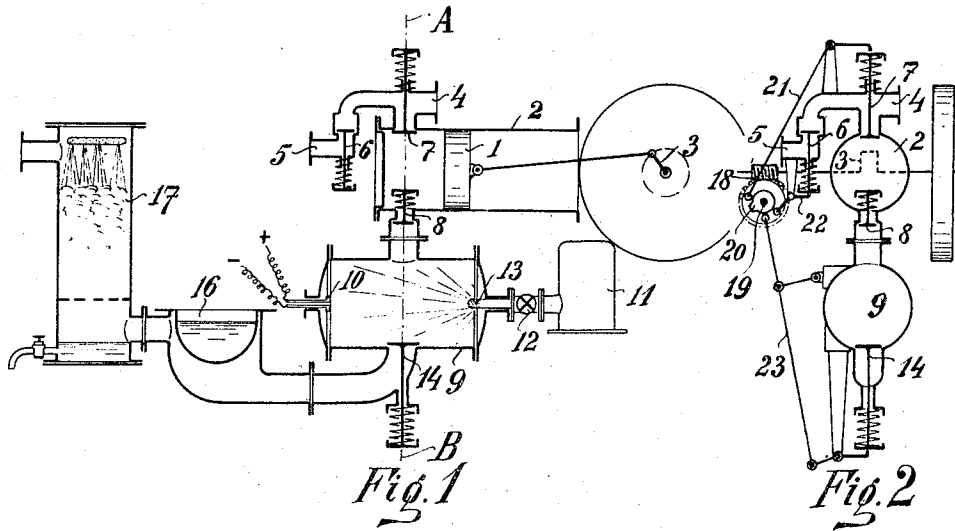


F. HÄUSSER.
PROCESS OF MAKING NITRIC OXID.
APPLICATION FILED JUNE 12, 1907

1,000,732.

Patented Aug. 15, 1911.



WITNESSES:
F. Stapel.
A. A. Moran

INVENTOR
Friedrich Häusser
BY J. Singer.
ATTORNEY

UNITED STATES PATENT OFFICE.

FRIEDRICH HÄUSSER, OF KAISERSLAUTERN, GERMANY.

PROCESS OF MAKING NITRIC OXID.

1,000,732.

Specification of Letters Patent. Patented Aug. 15, 1911.

Application filed June 12, 1907. Serial No. 378,537.

To all whom it may concern:

Be it known that I, FRIEDRICH HÄUSSER, residing at Kaiserslautern, in the Kingdom of Bavaria and German Empire, have invented new and useful Methods of Producing Oxid of Nitrogen by Means of Explosions, of which the following is a specification.

This invention relates to a method for producing oxids of nitrogen by means of explosions from a mixture containing nitrogen, oxygen and combustible gas or vapor.

The invention is an improvement on and a further development of a method for production of oxids of nitrogen, which is patented to me by United States Letters Patent 961,350 of June 14, 1910. In the said Letters Patent a method is disclosed for producing oxids of nitrogen by the explosive combustion of a combustible gas mixture within the cylinder of a combustion engine, the mixture expanding within the engine after the explosion and acting thereby upon the piston.

It is an object of the present invention to simplify the method disclosed in said patent and to avoid certain disadvantages which were connected with the method described in said patent.

The operation of an engine which transforms chemical energy into mechanical energy and which simultaneously produces oxids of nitrogen encounters many difficulties in practice.

It is therefore an object of the invention to produce oxids of nitrogen by means of explosions independently of a process which is performed for the sake of mechanical output power.

Another object is to use the heat of the exhaust gases for concentrating the produced nitric acid or salts of nitric acid.

In my invention the gases are discharged short time after the explosion without having spent their energy in the performance of mechanical work; by this means their temperature remains sufficiently high to allow of their use for concentration of the product. According to my present method the fresh mixture is conveyed into a separate explosion chamber preferably by means of a compressor, and the fresh charge is ignited in said chamber. The ignition chamber preferably is of sufficient size, so that the desired pressure therein before ignition is only obtained after several revolutions

of the crank shaft of the compressor. By this means the number of explosions is considerably less than the number of revolutions of the compressor, so that the number of operations of the exhaust valve in the ignition chamber, and consequently the wear and tear of said valve is reduced. The exhaust valve interposed between the cylinder of the compressor and the ignition chamber serves only for the passage of the compressed gases before the same have reached the temperature of ignition.

The drawing shows by way of example diagrammatically devices for performing my method of producing oxid of nitrogen.

Figure 1 shows diagrammatically a longitudinal section through one device. Fig. 2 is a section on line A—B of Fig. 1. Fig. 3 is a longitudinal section shown diagrammatically of a modified device. Fig. 4 is a diagrammatical view of a cam disk.

Piston 1 in the compressor cylinder 2 is actuated by the crank 3, a connecting rod being interposed between piston and crank. In its movement to the right in Fig. 1 the piston draws air or another mixture of oxygen and nitrogen by suction through conduit 4 into the cylinder 2, while a combustible preferably in gas or spray form is drawn in through conduit 5 connected with a suitable supply, not shown. The admission of the oxygen-nitrogen mixture is regulated by valve 7, while the admission of the combustible is controlled by valve 6.

For the sake of better illustration valve 6 in Figs. 1 and 3 is shown to be disposed in one plane with valves 7, 8 and 14 although this showing does not agree with that of Fig. 2. It is to be understood however that this is only done for the sake of better illustration.

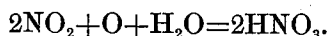
By the return stroke of the piston 1 to the left in Fig. 1, the mixture of air or nitrogen and oxygen with the combustible is conveyed through valve 8 into the explosion chamber 9. Valves 6, 7 and 8 are diagrammatically shown as spring controlled valves. This operation is repeated until the gases in the explosion chamber 9 have reached a certain pressure. The mixture is then exploded by means of an igniting device 10 and after having reached and maintained its maximum temperature for some time it is chilled rapidly to prevent decomposition of the nitric oxids formed during the explosion. The maximum temperature should not be

less than 1900 to 2000 degrees centigrade and it should remain at this point for some time. The chilling of the gases is effected by injecting into the explosion chamber a suitable cooling means, for this purpose water air, steam or such like may be admitted from a reservoir 11 through valve 12 which valve is opened at a suitable instant. It is advisable to distribute the cooling means in a fine spray through the interior of the chamber. For this purpose a nozzle 13 projects into the explosion chamber 9. The gases containing the nitric oxid are discharged from the explosion chamber through the exhaust valve 14 after which operation chamber is filled with a new charge from the cylinder 2.

In the modification illustrated in Fig. 3 the chilling of the gases is effected by conveying the same from the chamber 9 through the exhaust valve 14 into a receptacle 15 which is surrounded by cooling means.

Whatever be the method for chilling the gases, care must be taken either by selecting a suitable amount of injection means or by selecting a suitable size of the cooling area of the receptacle 15 respectively that the temperature of the gases does not fall below a temperature in which a decomposition of the nitric oxid might decrease the output. It is known that even at comparatively high temperatures, of about 1500 to 1600 degrees centigrade, the decomposition takes place slowly. It is sufficient therefore to chill the gases to about this temperature. The gases are still very hot and therefore may be used for purpose of concentration.

The exhaust gases leaving the explosion chamber 9 in Fig. 1 or the cooling receptacle 15 in Fig. 3 respectively are conveyed through concentrating devices 16. Flowing through these devices their temperature is lowered so far that the nitric oxid NO combines with the oxygen of the exhaust gases forming thereby dioxid of nitrogen NO₂. From the concentrating device the exhaust gases flow through the absorption apparatus 17 in which the dioxid of nitrogen is washed out by means of water, forming thereby a diluted nitric acid in accordance with the equation



During the explosion of the mixture of combustible gas and air or combustible gas and oxygen and nitrogen within the chamber and during the exhaust of the mixture therefrom the compressor operates without exerting any suction or compression in the cylinder 2. After the exhaust valve 14 has returned into closing position the compressor starts to operate in the way described above.

For the purpose of regulating the operation of the compressor in accordance with that of the valve 14 a cam shaft 19 is driven

from the shaft, on which the crank 3 is mounted, a worm gear 18 serving for the transmission. A plurality of cam disks are mounted on the shaft 19 one only being shown, said disk 20 actuating the valves 6, 7 and 14 by means of levers or links 21, 22 and 23. Springs secured to the valves serve for returning said valves automatically into closing position. The cam disks 20 on the shaft 19 are disposed so that the valves 6 and 7 are opened during the suction stroke of the compressor and that they remain closed while the piston presses the gases from the cylinder 2 into the explosion chamber 9. During the explosion of the gases in the chamber 9 and during the exhaust period of the same from said chamber, in which period valve 14 is opened, valve 6 remains closed. It is obvious therefore that during this period no fuel is conveyed into the cylinder 2. The valve 7 however remains open so that the piston may draw air into the cylinder 2 and may expel the same therefrom through the air conduit 4. After the gases are discharged from the chamber 9 and after valve 14 has returned to closing position valves 6 and 7 are actuated again as stated above.

The method described is more clearly explained by the following data, obtained from actual working on a basis of experiments in a laboratory. The explosion chamber had a volume of 1.7 liters and was filled with a mixture of illuminating gas and air, said ingredients being present in the mixture in a ratio of 1:6.4. The pressure in the chamber amounted to 2.6 atmosphere. This pressure increased to 24.5 atmosphere after the ignition of the gases and the temperature of the explosion arose to about 1880 degrees centigrade. This temperature remained approximately constant for about 1/10 of a second. After this period of constancy 60 cubic centimeters of water were injected into the explosion chamber chilling thereby the gases rapidly to a temperature of about 900 degrees centigrade. The acid produced by these experiments was very weak as a large amount of injection medium was used. It contained about 3/10 gram nitric acid to 100 grams water. One cubic meter of illuminating gas gave an output of about 100 to 115 grams nitric acid.

I claim:

1. A method for making nitric acid, which consists in compressing a mixture of nitrogen, oxygen and a combustible into a separate ignition chamber, igniting the mixture therein, allowing the temperature to rise to the point necessary for producing nitric oxid and allowing the temperature to remain until the nitric oxid is produced, suddenly causing the temperature to drop to a point slightly below the temperature at which the nitric oxid is decomposed, con-

verting the nitric oxid into dilute nitric acid and concentrating the same by the heat of said exhaust gases.

2. A method for making nitric acid which
5 consists in compressing a mixture of nitrogen, oxygen and a combustible, conveying the compressed mixture into an ignition chamber, igniting the mixture therein, allowing the temperature to rise to the point
10 necessary for producing nitric oxid and allowing the temperature to remain until the nitric oxid is produced, suddenly causing the temperature to drop to a point below the temperature at which the nitric oxid is de-
15 composed, converting the nitric oxid into dilute nitric acid and concentrating the same by the heat of said exhaust gases.

3. A method for making nitric oxid, which consists in compressing a mixture of nitro-
20 gen, oxygen and a combustible conveying the compressed mixture into an ignition chamber, igniting the mixture therein, allowing the temperature to rise to the point necessary for producing nitric oxid and al-
25 lowing the temperature to remain until the nitric oxid is produced, suddenly causing the temperature to drop to a point below the temperature at which the nitric oxid is de-
30 composed and discharging the gases resulting from the ignition.

4. A method for making nitric oxid, which consists in compressing a mixture of nitro-
35 gen, oxygen and a combustible agent, forcing the compressed mixture into an ignition chamber until the mixture in said chamber is at a predetermined pressure, igniting the mixture, allowing the temperature to rise to the point necessary for producing nitric
40 oxid and allowing the temperature to remain until the nitric oxid is produced, suddenly causing the temperature to drop to a point below the temperature at which the

nitric oxid is decomposed and discharging the gases resulting from the ignition.

5. The process for producing oxids of 45 nitrogen by means of explosive combustion from a compressed mixture of nitrogen, oxygen, and a combustible gas or vapor, consisting in first compressing the said mixture, then forcing the compressed mixture 50 into an ignition chamber until a predetermined pressure has been attained therein, then exploding the mixture, maintaining the high temperature of explosion constant for a sufficiently long period to permit the 55 formation of oxids of nitrogen, then passing the gaseous products of combustion into a cooled receptacle, thereby chilling the same and preventing decomposition of the oxids of the nitrogen, and finally causing the said 60 products of combustion to pass through a concentrating apparatus for the purpose of concentrating the aqueous nitric acid.

6. A method for making nitric oxid, which consists in compressing a mixture of nitro- 65 gen, oxygen and a combustible, conveying the compressed mixture into an ignition chamber, igniting the mixture therein, allowing the temperature to rise to the point 70 necessary for producing nitric oxid and allowing the temperature to remain until the nitric oxid is produced, conveying the gases resulting from the ignition into a cooled vessel, to lower the temperature to a point 75 below the temperature at which the nitric oxid is decomposed, and discharging the gases.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRIEDRICH HÄUSSER.

Witnesses:

WOLDEMAR HAUPT,
HENRY HASPER.