

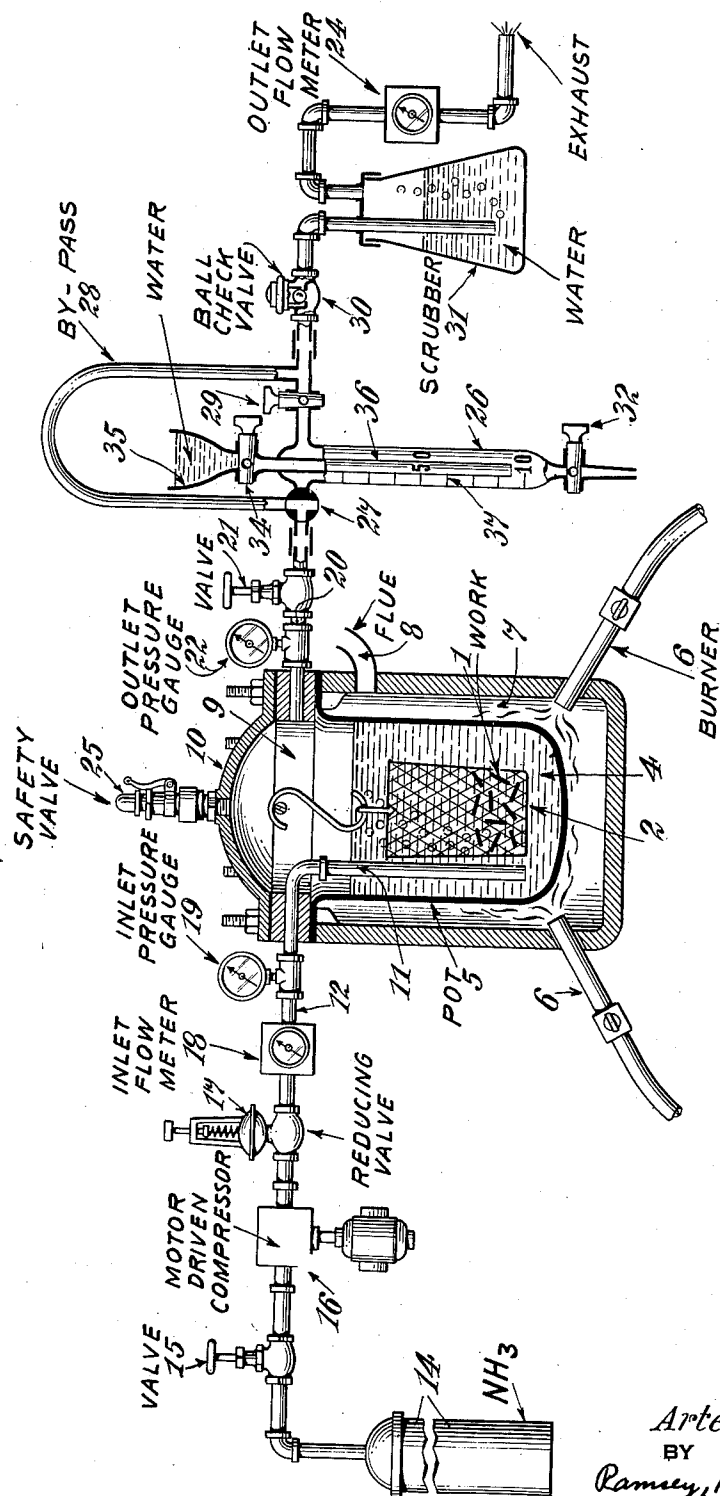
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A. F. HOLDEN

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NITRIDING STEEL

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INVENTOR
Artemas F. Holden
 BY
Ramsey, Kent & Chisholm
 HIS ATTORNEYS

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NITRIDING STEEL

Artemas F. Holden, New Haven, Conn.

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2 Claims. (Cl. 148—15)

The present invention relates to the hardening of finished steel parts to the depth of several thousandths of an inch by causing the penetration of nitrogen into the steel parts. Nitriding of steel may be carried out at from 900° F. to 1200° F. and thus is accomplished at temperatures well below the critical point of steel and the danger of distortion of the parts is thus avoided.

The figure of the drawing illustrates diagrammatically one form of apparatus for carrying out the present invention.

The present invention is carried out in a sealed pot under pressure with the parts being treated submerged in a suitable salt bath, through which anhydrous ammonia is bubbled under pressure during the treatment.

The parts being treated are preferably made from alloy steel, and more especially a steel alloy particularly adaptable to nitriding, as for example, steel known as "Nitalloy," which is an alloy of steel with nickel, chrome, molybdenum, and aluminum. It is to be understood that this invention is applicable to any metal that may be nitrided. The particular steel used in the operations, on which the data herein given are based, was a type of "Nitalloy" commercially designated as type No. 135, and is steel containing carbon .38% to .45%; manganese .40% to .70%; aluminum .95% to 1.35%; chromium 1.40% to 1.80%; and molybdenum .30% to .45%.

The salt baths which are preferred to carry out the present invention are salt baths containing cyanide, preferably potassium, calcium, or sodium cyanide, and other salts to make up a bath that operates at the desired range of temperatures. The preferred bath is one made from the combination of potassium chloride 15% to 30%; sodium cyanide 20% to 50%; sodium carbonate 15% to 30%; potassium carbonate 15% to 30%; sodium fluoride 2% to 10%. The particular preferred bath used in the present case is a bath comprising potassium chloride 20%, sodium cyanide 36%, sodium carbonate 20%, potassium carbonate 19%, and sodium fluoride 5%.

The pressures used in the pot where the parts are submerged in the molten salt bath may vary from one inch water column pressure to one hundred and fifty pounds per square inch. In the present case the pressure used was from one inch water column to one hundred pounds to the square inch, and the anhydrous ammonia gas was introduced through an iron pipe extending to the bottom of the pot so that the gas bubbled up through the hot liquid bath and the excess gas, which was largely composed of hydrogen, 55

nitrogen and undecomposed ammonia, was carried away through an exhaust pipe. The amount of gas used in a given time may vary with the size or volume of the salt bath, but it appears to be sufficiently supplied if the amount supplied is such as to maintain the bath constant, i. e., where the bath at the termination of the treatment period is of the same chemical materials in substantially the same proportions as at the start of the operations, with the exception, that some carbon may be found in the bath as a result of the reaction of the anhydrous ammonia with the chemicals of the salt bath. This end is attained where the ammonia gas is kept bubbling through the salt bath during the treatment period.

The temperature in the pot was maintained at approximately 975° F. to 1000° F. and the "Nitalloy" steel parts, while submerged in the salt bath specified, were treated for ten hours, then cooled gradually in air without quenching. The result was the nitriding of the parts to a depth of about fourteen thousandths of an inch with a hardness of from 89 to 93 Rockwell superficial "N" scale. This compares with the nitriding of the same material for forty to sixty hours, in a muffle furnace, including the cooling cycle. It was thus seen that by the use of the present invention the nitriding was accomplished in one fifth or less the usual time.

Referring now to the drawing, wherein is illustrated diagrammatically one form of apparatus for carrying out the present invention, the work 1, being treated, is supported, as by a basket 2, in the salt bath 4, within the pot 5, which may be the usual iron pot used for salt baths. The salt bath 4 may be heated from 900° F. to 1200° F. in any manner common in the art, as for example, electrically, by gas, or oil (the particular means for heating the bath forms no part of the present invention), and is illustrated as being heated through the pot 5 by gas burners 6 which extend into the heat chamber 7 from which the products of combustion are carried away by a flue 8. A header 9 may be placed over the pot 5 and a suitable cover 10 may be sealed over the header 9. All joints are sealed against pressure by suitable gaskets. A pipe 11 carried by the header extends downward near the bottom of the pot 5 and is connected by a line of piping 12 with a pressure tank 14 containing commercial anhydrous ammonia gas. A valve 15 may control the exit of the ammonia gas from the tank 14 and may lead to a motor driven (preferably electric) compressor 16. This compressor 16 may be used to increase the pressure of the ammonia gas

where the pressure from the tank 14 is not sufficient to produce the pressure desired in the sealed pot 5. An adjustable reducing valve 17 maintains the pressure in the pipe line to the pot at the desired amount. An inlet flow meter 18 may be provided to show the amount of gas being used during the nitriding of the work, and a pressure gauge 19 shows the pressure of the ammonia gas being fed to the pot. An exhaust pipe line 20 leads through the header 9 to the interior of the pot 5 and may conduct the exhaust gases from the pot 5 to atmosphere or other disposal medium. A valve 21 in this pipe line 20 may be partially closed to maintain the desired pressure within the pot 5, and a pressure gauge 22 shows the pressure between the valve 21 and the pot 5. Ordinarily the pressure gauge 19 in the inlet pipe line 12 and the pressure gauge 22 in the exhaust pipe line 20 will have somewhat similar readings except for the resistance to the incoming gas by the consistency and head of the salt bath 4 through which the gas is being forced, and the outlet flow meter 24 shows the volume of exhaust gases. A suitable safety valve 25 may be provided to insure that excessive pressure will not develop within the sealed pot.

A test gauge 26 is mounted in the exhaust line whereby the exhaust gases may be tested from time to time, at intervals, preferably, of one hour each during the operation of the pot. Normally the two-way valve 27 is set as shown in the drawing to cause the exhaust gases to flow around the test gauge 26 by going through the by-pass 28, with the valve 29 closed. The exhaust gases flow through the ball check valve 30 to and through a water filled scrubber 31, then to and through the outlet flow meter to the final point of disposal. The ball check-valve 30 prevents any possibility of drawing water from the scrubber 31 back into the pot and causing an explosion in case, if for any reason, a negative pressure should develop in the pot.

When a test is to be made while the anhydrous ammonia is bubbling through the salt bath in the pot, the two-way valve 27 is turned counterclockwise to close the by-pass 28 and admit exhaust gases to the test gauge 26 as the exit valve 32 is opened and the valve 29 is closed. When all the air is expelled from the test gauge 26 and this gauge is filled with exhaust gases, the exit valve 32 is closed and the two-way valve 27 is turned clockwise to seal the test gauge 26 and open the by-pass 28 to permit free flow of the exhaust gases through the by-pass 28. Thus the test gauge is filled and sealed, full of the exhaust gases. The water valve 34 is now opened and water from the font 35 falls down, through the pipe 36, into the test gauge 26. The free anhydrous ammonia is quickly absorbed in the water and the water rises in the test gauge 26 until it is stopped by the trapped gases that are not quickly or easily absorbed by the water. The test gauge 26 is provided with a suitable scale 37 on which a reading of the water level in this gauge may be taken. From this reading the operator may determine the amount of anhydrous ammonia gas being required to nitride the work and may also determine if there is excessive waste of this anhydrous ammonia gas. Comparisons of successive readings may also enable determination of the stage of nitriding of the work being treated. At the conclusion of each test reading from the test gauge 26 the valves 32 and 34 are opened to permit the water to run off and then

valve 34 is closed and the font 35 is filled with fresh water.

The several meters, valves and gauges give the operator complete control of the entire process, and full information of the progress of the treatment of the work.

Nitriding of the parts being treated appears to take place at the same rate and in the same amount regardless of whether the parts are in the path of flow of ammonia gas bubbling through the bath or remote from this line of bubbles. Where salt baths containing cyanides were used, the gases emitted from the exhaust pipe 20 are predominantly hydrogen, and the composition of the baths 4 do not appear to substantially change from the beginning to the end of the operations. Also the application of pressure speeds up the nitriding operation. These facts lead to the conclusion that the cyanide in the salt bath, being in intimate contact with the work, and the bath being very liquid when heated to 900° F. or higher, appears to break down and enables the nitrogen from the cyanide to penetrate the steel parts. The anhydrous ammonia gas bubbling through the hot liquid bath seems also to break-down and the nitrogen from this gas appears to reform the cyanide that has been broken down. This probably releases hydrogen molecules from the gas and thus accounts for the hydrogen that is expelled through the exhaust pipe together with the excess of anhydrous ammonia gas not needed to maintain the reactions constant.

The principal factors in the present invention appear to be a salt bath capable of liquefaction at a temperature below the critical point of the steel being treated; a material in the bath with or without nitrogen molecules adaptable to produce nitriding by the interaction of anhydrous ammonia, which material imparts the nitrogen to the steel parts being treated releasing this nascent nitrogen while the bath is operating, and a sealed vessel wherein the bath and the parts being treated are under pressure to effect operation at a rapid rate. When the treatment period is ended, the pressure is reduced to that of the atmosphere, and the treated parts are removed from the bath and are allowed to cool without quenching. The nascent nitrogen forms a hard surface layer on the treated metal, and the parts are hardened without distortion. This hardened layer is of a depth of several thousandths of an inch, dependent upon the pressure, the heat (which should not exceed the critical point of the steel), and the length of time which the parts are treated.

Exactly what occurs during the operations is not definitely known but the explanations herein given are believed to be correct.

Having described my invention, I claim:

1. The method of rapid nitriding for steel objects the properties of which are improved by surface absorption and retention of nitrogen, which comprises: providing a cyanide-rich eutectic salt bath which is liquid at 900° F. and subjecting said bath to a sustained pressure of from one inch water column to one hundred and fifty pounds per square inch while maintaining same at a temperature within the range of 900° F. to 1200° F., maintaining the nitridable steel object under immersion in said thus-heated and pressurized liquid salt bath, bubbling anhydrous ammonia gas through the thus-pressurized and heated salt bath while the steel object to be nitrided is immersed therein, and simultaneously drawing off gas consisting primarily of decom-

position products from the thus-ammoniated steel-immersed pressurized and heated bath at a rate so proportioned to the rate of ammonia introduction into and nitrogen absorption from the bath as to maintain the bath and its immersed object under the stated pressure condition throughout the nitriding treatment of the latter without appreciable modification of the cyanide content of the bath, and finally removing said object from said pressurized and heated bath to cool same when the desired degree of nitriding has been accomplished therein by said pressurized and heated ammoniated bath.

2. The method of rapid nitriding for steel objects the properties of which are improved by surface absorption and retention of nitrogen, which comprises: providing a salt bath having the composition: potassium chloride 15% to 30%, sodium cyanide 20% to 50%, sodium carbonate 15% to 20%, potassium carbonate 15% to 30% and sodium fluoride 2% to 10%; subjecting said bath to a sustained pressure of from one inch water column to one hundred and fifty pounds

while maintaining same at a temperature within the range 900° F. to 1200° F., maintaining the nitridable steel object under immersion in the thus-heated and pressurized salt bath, bubbling anhydrous ammonia gas through the thus pressurized and heated salt bath while the steel object to be nitrided is immersed therein, and simultaneously drawing off gas consisting primarily of decomposition products from the thus-ammoniated steel-immersed pressurized and heated bath at a rate so proportioned to the rate of ammonia introduction into, and nitrogen absorption from, the bath as to maintain the bath and its immersed object under the stated pressure condition throughout the nitriding treatment of the object without effecting appreciable changes in the original composition of the salt bath at the inception of treatment, and finally removing said object from said pressurized and heated bath to cool same when the desired degree of nitriding has been accomplished therein by said pressurized and heated ammoniated bath.

ARTEMAS F. HOLDEN.