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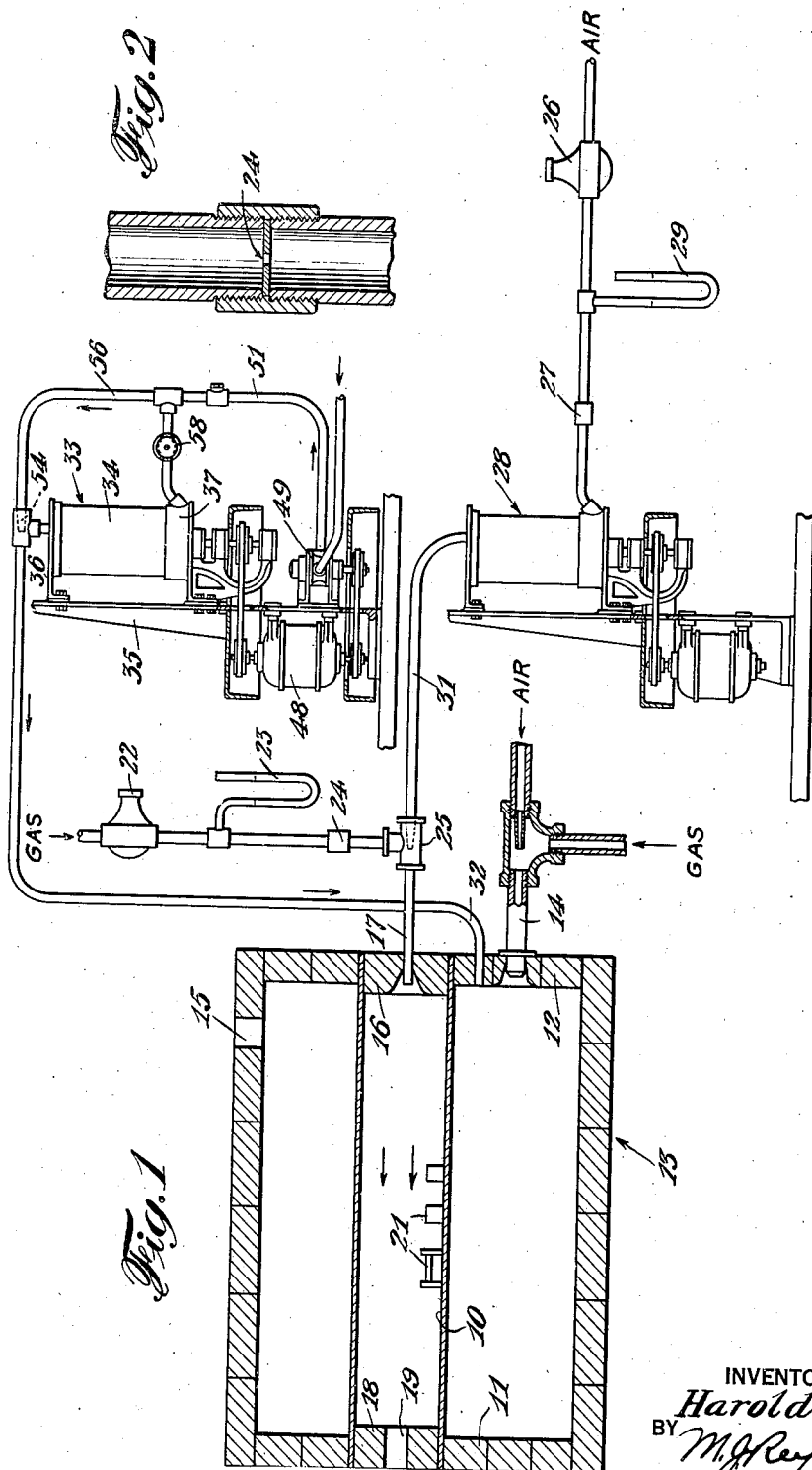
H. J. NESS

2,240,146

CARBURIZING FERROUS METALS

Filed Oct. 6, 1938

2 Sheets-Sheet 1



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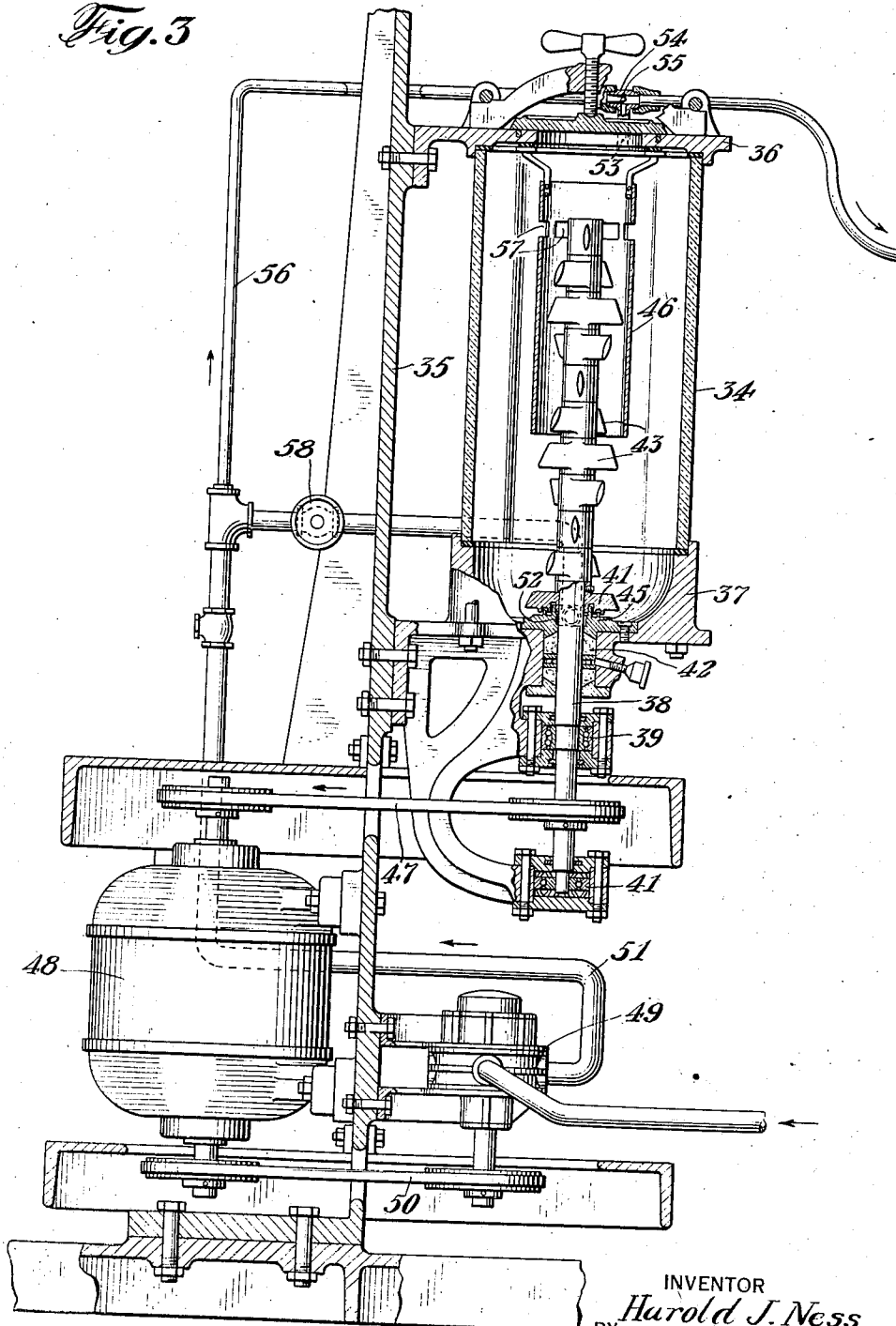
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Fig. 3



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CARBURIZING FERROUS METALS

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Application October 6, 1938, Serial No. 233,637

9 Claims. (Cl. 148—17)

This invention relates to the case hardening of ferrous metals and more particularly to the carburizing of such metals.

There are in general use at the present time two main methods of carburizing ferrous metals, namely, gas carburizing and pack carburizing.

In the former of these methods the ferrous metal parts are heated in a muffle or retort to a temperature of about 1700° F. in a carburizing gas, such as a hydrocarbon gas or a mixture of a hydrocarbon gas and carbon monoxide, diluted with from 60% to 75% air. In pack carburizing the work is packed in metal boxes containing a carburizing compound, such as charcoal, bone dust, leather, etc., and heated to about 1700° F. The exact carburizing temperature depends among other things, upon the nature of the iron or steel being carburized, the carbon content of the case desired and the exact composition of the carburizing agent. The rate of penetration, after the work is brought up to the carburizing temperature, is about the same by either method and at 1700° F. it normally requires a period of approximately eleven hours to obtain a penetration of .08 inch. The gas carburizing method has certain advantages over the pack method. For instance, it permits better control of the case characteristics and requires less time to bring the work up to heat and to subsequently cool the same since it is unnecessary to heat and cool the container and large masses of carburizing compounds used in pack carburizing. It has the disadvantage, however, of producing a considerable amount of scale or oxidation of the parts, due apparently to the free oxygen and water vapor always present in the carburizing gases, even slight traces of which are sufficient to affect the work. To reduce to a minimum the scaling of the work, it is customary to take extreme precautions to dry the air and gas and to employ a relatively pure gas, such as dried purified propane. However, since it is not commercially possible to completely dry the gas and air and moreover since carbon monoxide can readily react with hydrogen to form more water vapor, this step is not sufficient to prevent heavy scaling of the parts, and it is usually necessary to remove the scale and hard carbon deposit resulting from gas carburization, by sand blasting, machining, or other mechanical means. For these reasons, gas carburizing is not used as extensively as it otherwise would be. While pack carburizing does not result in as severe oxidation of the parts as gas carburizing, it is nevertheless accompanied

by some scaling and deposition of hard carbon thereon which must be mechanically removed.

One of the objects of the present invention is to overcome the disadvantages heretofore met in both gas and pack carburizing and to provide a carburizing method in which scaling or oxidation of the iron or steel is eliminated.

Another object is to reduce the time required to obtain a desired case on the work.

A further object is to increase the rate of penetration of the carbon into the work.

A still further object is to produce a method of carburizing ferrous metals in which mechanical cleaning of the parts after carburization is not required.

Another object is to effect an economy in the carburizing of ferrous metals.

Another object is to provide a carburizing process which permits the easy removal of the carbon deposit from the work, after carburizing.

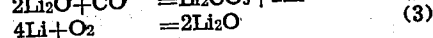
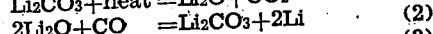
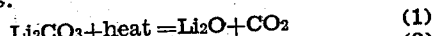
Still another object is to eliminate the necessity for using gas and air drying or purifying equipment for generating or treating carburizing gases.

Still another object is to provide a process of producing carburizing gas atmospheres in the carburizing chamber free from free oxygen.

Another object is to produce a more uniform carburizing of ferrous metals.

Other objects and advantages will hereinafter appear.

In a copending application Ser. No. 186,941, filed Jan. 26, 1938, and entitled "Heat treatment of ferrous metals," I have described a method of heat treating iron and steel in an atmosphere containing lithium, preferably produced by the reduction of a lithium compound, such as lithium carbonate, by heat and the furnace gases. As set forth in said application, the presence of lithium vapor in the atmosphere of an ordinary gas or oil fired furnace eliminates free oxygen from the furnace, the reactions apparently being as follows:



The lithium produced by reaction 2 combines with free oxygen reaction 3 in the furnace to form lithium oxide, which in turn combines with the carbon monoxide according to Equation 2 to again liberate part of the lithium to repeat the cycle and the lithium carbonate of reaction 2 is again broken down by heat liberating lithium oxide. The reaction is thus repeated and a small

amount of lithium carbonate introduced into the furnace throughout the heat treating process is effective to maintain a very large volume of furnace gases free of oxygen, thus preventing oxidation and decarburization of the work. In addition to maintaining the atmosphere free of oxygen, the lithium oxide and lithium carbonate in the furnace atmosphere condense onto the work forming a coating thereon. In accordance with the theory set forth in said above application this coating further assists in protecting the parts physically from decarburization and oxidation. Whatever the reason, exhaustive tests have proven that in an ordinary furnace atmosphere, such as a gas or oil fired furnace, operated slightly reducing, to insure the presence of carbon monoxide therein, the presence of lithium vapor in the furnace prevents all oxidation, carburization or decarburization of the metal parts.

It has now been discovered that in a carburizing gas atmosphere, either as produced in a retort or muffle furnace or within the boxes in which the parts are packed in pack carburization, the presence of lithium promotes carburization. This is due to the different composition of the gas carburizing atmosphere. For instance, in the gas carburizing atmosphere the mixture of hydrocarbon gas and air is such as to have a very low carbon dioxide and free oxygen content and a high carbon monoxide content. As a result the free lithium, resulting from reaction 2 supra, has but a small amount of oxygen with which to combine and thus only a relatively small amount of lithium oxide is formed. Since the lithium carbonate originally introduced into the retort or work containing chamber is quickly converted to lithium metal as per reactions 1 and 2, there is only a small amount of condensation of lithium oxide and lithium carbonate on the parts and they are, therefore, not physically protected against the action of the carburizing gases, particularly in the presence of a rich carburizing atmosphere. There is some condensation of lithium oxide and lithium carbonate, however, concurrently with the deposit of soot or carbon on the work and as a consequence the carbon may be readily removed by acid, the effect of which is to dissolve out the lithium compounds, thus loosening the carbon whereby it readily falls off. This lithium compound deposit also protects the parts against oxidation if it is desired to cool them in air.

The presence of lithium in the atmosphere greatly accelerates carburization of the work. For example, in a sample of chromium-molybdenum steel containing approximately 0.15% carbon, which ordinarily requires about eleven hours for a penetration of 0.08 inch, at 1700° F. in a gas carburizing furnace, the same penetration was obtained in about three hours, in the presence of lithium vapor. While some soot or carbon deposit is obtained in carburizing in a lithium atmosphere, it appears to form at a slower rate than in a normal unliothiated gas carburizing process and to be of a softer nature, readily falling from the parts during the usual quench following the carburizing process or may be removed with acid as stated heretofore. It is suggested that the reason for such increased rate of penetration of the carbon in the presence of lithium is due to the complete absence of scale or oxidation on the surface of the work, and to the more pervious nature of the carbon whereby the carburizing gas has better access to the work.

The amount of lithium carbonate required in 75

a gas carburizing atmosphere to effect this acceleration of the carburization and to prevent oxidation or scaling of the work is extremely small, being even less than that required to protect parts during heat treatment in an ordinary combustion furnace. The amount is not critical, however, and may be determined by test with a particular furnace. It may be of the order of magnitude of 0.01 oz. per cu. ft. of the carburizing gas employed.

In order that a better understanding of the invention may be had reference will be made to the accompanying drawings in which:

Fig. 1 is a vertical sectional view of a muffle furnace, having provisions for producing a lithium atmosphere therein;

Fig. 2 is a sectional view of a simple orifice device to facilitate the obtaining of a proper carburizing gas and air mixture in the furnace; and

Fig. 3 is a vertical sectional view of an atomizing device for supplying a lithium compound to the furnace at the required rate.

Referring first to Fig. 1, I have shown a typical muffle furnace of the stationary retort type although it is to be understood that the invention is equally applicable to a rotating retort type or to retort or muffle furnaces of the continuous type. The furnace shown comprises a retort 10, which may be of steel, for a reason which will hereinafter appear, or of a heat-resisting alloy, such as a nickel-chromium alloy, or it may consist of a refractory oxide such as magnesite, chromium oxide or sulphur free silicon carbide. The retort 10 is supported on the end walls 11 and 12 of the surrounding furnace 13. The furnace 13 is built up from suitable refractories to form a heating chamber about the retort 10 and is provided, in the base thereof, with a burner 14 for burning either oil or gas. The furnace gases, after circulating about the retort 10, escape through a suitable vent 15. One end of the retort 10 is closed by a refractory member 16 through which a tube or nozzle 17 extends by which the carburizing gas mixture is introduced into the retort. The opposite end of the retort is closed by a refractory member 18 having a vent 19 for the escape of the gases in the retort. The member 18 is readily removed to permit introduction of the work 21 into the retort.

A carburizing gas, such as propane, butane, natural or city gas or any hydrocarbon gas suitable for carburizing, is supplied through a pressure regulating valve 22. A manometer 23 or other pressure measuring device is provided adjacent the valve 22. The gas, the pressure of which has been so regulated, passes through a choker or orifice device 24 of predetermined size whereby a calculated volume of the gas will flow there-through into the air and gas mixer 25. Air under pressure is supplied through a similar pressure regulating valve 26 and orifice device 27 to an atomizing device 28 wherein the air becomes laden with a compound of lithium, such as lithium carbonate. A manometer 29 enables the air pressure to be determined. The air laden with the lithium compound is conducted from the atomizer 28 by a conduit 31, extending into the mixer 25 where it becomes mixed in the proper proportion with the carburizing gas. A mixture of approximately two parts of air to one part of propane has been found satisfactory. The gas and air mixture is broken down in the retort, by the external heat, into carbon, carbon monoxide, water vapor, methane, hydrogen, etc., depending on the particular gas employed. As stated, the

lithium compound is converted into the oxide form by heat and this in turn is converted into the metallic form by reaction with carbon monoxide in the retort. The lithium vapor so produced eliminates free oxygen in the retort preventing scale formation. Whatever the precise action of the lithium, in the carburizing process, it reduces the time of carburization to approximately a third of that normally required for producing a definite case characteristic.

The mixture within the retort 10 is, of course, a non-flammable one and it is necessary therefore to consume the gases as they vent through the opening 19 although, if desired, the exhaust gases may be collected and with additional air added, be supplied to the burner 14.

Due to the presence of lithium in the retort 10 the inner surface thereof will be protected against oxidation even though composed of ordinary steel or iron. The outer surface may likewise be protected by introduction of a lithium compound into the furnace gases surrounding the retort, as for instance through a conduit 32 terminating adjacent the burner 14. The manner of obtaining a protective lithiated atmosphere in combustion furnaces is fully set forth in my aforesaid application Ser. No. 186,941. Briefly, the furnace is operated slightly reducing and a sufficient quantity of a lithium compound, such as lithium carbonate, is introduced into the furnace to produce a rich scarlet color in the flame. When employing lithium in the external heating chamber, it is necessary to employ a refractory for all parts of the furnace which is basic or neutral to lithium, such as magnesium oxide or chromi-oxide. If desired, a porous insulating brick, either alone or provided with a denser coating or layer on its inner surface of one of such refractory materials, may be used. The use of lithium in the external furnace gases in addition to permitting ordinary iron or steel retorts to be used in place of the usual expensive nickel-chromium alloys, also increases the efficiency of combustion as fully set forth in my application Ser. No. 154,203, filed July 17, 1937, and entitled "Promotion of combustion." The atomizer 28 may be employed for supplying the lithium compound both to the mixer 25 and the conduit 32, by providing suitable means for controlling the volume of air and compound supplied to each of the conduits 31 and 32 but I prefer to employ a separate atomizer 33 through which either air or gas or a combustible mixture thereof may be passed.

The atomizers 28 and 33 may be of the form shown in my copending application Ser. No. 209,855, filed May 25, 1938, and entitled "Atomizing device for pulverulent material," and in Fig. 3 I have shown a modification of the atomizer described in the aforesaid application. Briefly, the atomizer comprises a container 34 for the powder to be atomized, secured to an upright 35 between upper and lower brackets 36 and 37. The container 34 consists of a cylindrical tube, preferably of transparent material. A shaft 38, carried in bearings 39 and 41, extends into the container 34 through a packing gland 42 and mounted on the shaft 38 is a series of upwardly pitched blades or screw 43. A pair of labyrinth members 44 and 45 prevents migration of powder from the container into the gland 42. A stack or cylinder 46, spaced from the walls of the container, surrounds the upper portion of the blades or screw 43. The shaft 38 is driven by a belt 47 from a motor 48. In the case of the atomizer 28, the air line extends directly into the container 34 through the

lower bracket 37 and passes out through an orifice in the upper bracket 36, connected to the conduit 31. In the case of the atomizer 33, the air is compressed by a blower 49 of a type which operates without oil. The blower 49 is driven by the motor 48 through a belt 50. A conduit 51 extends from the blower 49 into the base of the bracket 37, being continued through the bracket and terminating in a recess 52 surrounding the shaft 38 between the gland 42 and the lower labyrinth member 45. The air or gas under pressure thus passes into the container between the labyrinth members. An outlet 53 provided through the top bracket 36 extends into an inspirator 54, through the nozzle 55 of which a portion of the compressed air is by-passed by conduit 56. In operation, the blades or screw 43 raises the powdered compound causing it to pass over the top of the stack and through the apertures 57 therein in a fine suspension in the air or gas in the chamber. A portion of the compound passes with the air or gas through the conduits 31 or 32, as the case may be. The amount of lithium compound introduced into the conduit 32 is controlled by the valve 58.

While the specific embodiment has been described with particular reference to gas carburizing, it is to be understood that the principles of the invention apply also to pack carburizing. In the latter instance the retort 10 and its controlled lithiated atmosphere is omitted and the packed boxes containing the work and the carburizing compounds are disposed on a hearth or other support in the combustion chamber. The lithium atmosphere provided by the atomizer 33 pervades the entire furnace and protects the boxes from oxidation thereby permitting ordinary iron or steel boxes to be used. It moreover seeps into the boxes, mingling with the carburizing compound therein and effecting the same advantageous results obtained in the retort 10.

The parts after removal from the retort 10 or from the boxes if pack carburizing is employed, may be cooled in air to the desired temperature and then quenched in oil. As stated, during this quenching the carbon deposit on the parts falls off leaving them clean. In case quenching is not desired, the carbon may be removed by dissolving out the lithium oxide or lithium carbonate deposited therewith, in acid, as heretofore stated, or it may be removed by heating the parts after carburizing in the usual neutral lithiated heat treating atmosphere, such as set forth in my aforesaid application Ser. No. 186,941, and described above with reference to the external heating of the retort 10. The time and temperature of the heating in the lithium atmosphere necessary to remove the carbon depends, of course, on the amount of soot or carbon on the parts. A temperature of approximately 1500° F. is effective to remove the carbon deposit at a relatively fast rate. This latter method of removal of the carbon is particularly important in connection with the carburizing of iron powder for use in powdered metallurgy, as for instance, in the production of steel from mixtures of iron powder and powdered iron carbide, as set forth in a copending application of F. H. Clark et al., Ser. No. 225,844, filed Aug. 20, 1938, and entitled "Metallurgy of ferrous metals." In place of lithium carbonate, other lithium compounds which are reduced to the oxide under the conditions existing in the furnace may be employed, such as lithium chloride, lithium hydroxide, lithium fluoride, lithium oxalate, etc. Lithium oxalate decom-

poses in the furnace, generating a supply of carbon monoxide, which then serves as a carburizing medium, permitting the supply of other carburizing gases to be reduced in proportion to the amount of lithium oxalate employed. The term "lithium" as employed in the appended claims is intended to include either elemental lithium or a compound containing lithium.

Of course, the retort 10 may be heated electrically, if desired, as is well understood in the art. In such case the lithiated atmosphere about the retort may be provided in the manner set forth in my copending application Ser. No. 143,411, filed May 19, 1937.

Numerous changes in the equipment employed and the details of the process may be made, of course, without departing from the essentials of the invention and I do not desire to be limited thereto or to the specific embodiment shown and described.

What I claim is:

1. The method of carburizing ferrous metals which comprises heating said metals to the carburizing temperature in a continuous flow of a gaseous carburizing medium containing lithium.

2. The method of carburizing ferrous metals which comprises heating said metals to the carburizing temperature in the presence of a flow of a carburizing hydrocarbon gas containing lithium.

3. The method of carburizing ferrous metals which comprises heating said metals to the carburizing temperature in a moving gaseous environment containing carbon, carbon monoxide, methane and lithium metal.

4. The method of carburizing ferrous metals which comprises heating said metals in a chamber to the carburizing temperature, and substantially continuously introducing lithium and a carburizing gas into the chamber during the heating.

5. The method of increasing the rate of penetration of combined carbon into ferrous metals comprising heating said metals to a carburizing temperature and flowing a carburizing gas containing lithium thereabout.

6. The method of carburizing ferrous metals which comprises heating said metals to the carburizing temperature in the presence of a flow of a carburizing gas and introducing lithium carbonate into said gas during the heating.

7. The method of promoting carburization of ferrous metals comprising heating said metals in a flowing gaseous carburizing environment and introducing therein lithium in sufficient quantity to eliminate free oxygen from said gaseous environment.

8. The method of carburizing ferrous metals which comprises heating said metals to the carburizing temperature in the presence of a flow of a carburizing gas and introducing lithium oxalate into said gas during the heating.

9. The method of carburizing ferrous metals comprising heating said metals to the carburizing temperature in an enclosed chamber by externally applied heat and introducing a carburizing carbonaceous gas mixture and lithium into said chamber during the heating.

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