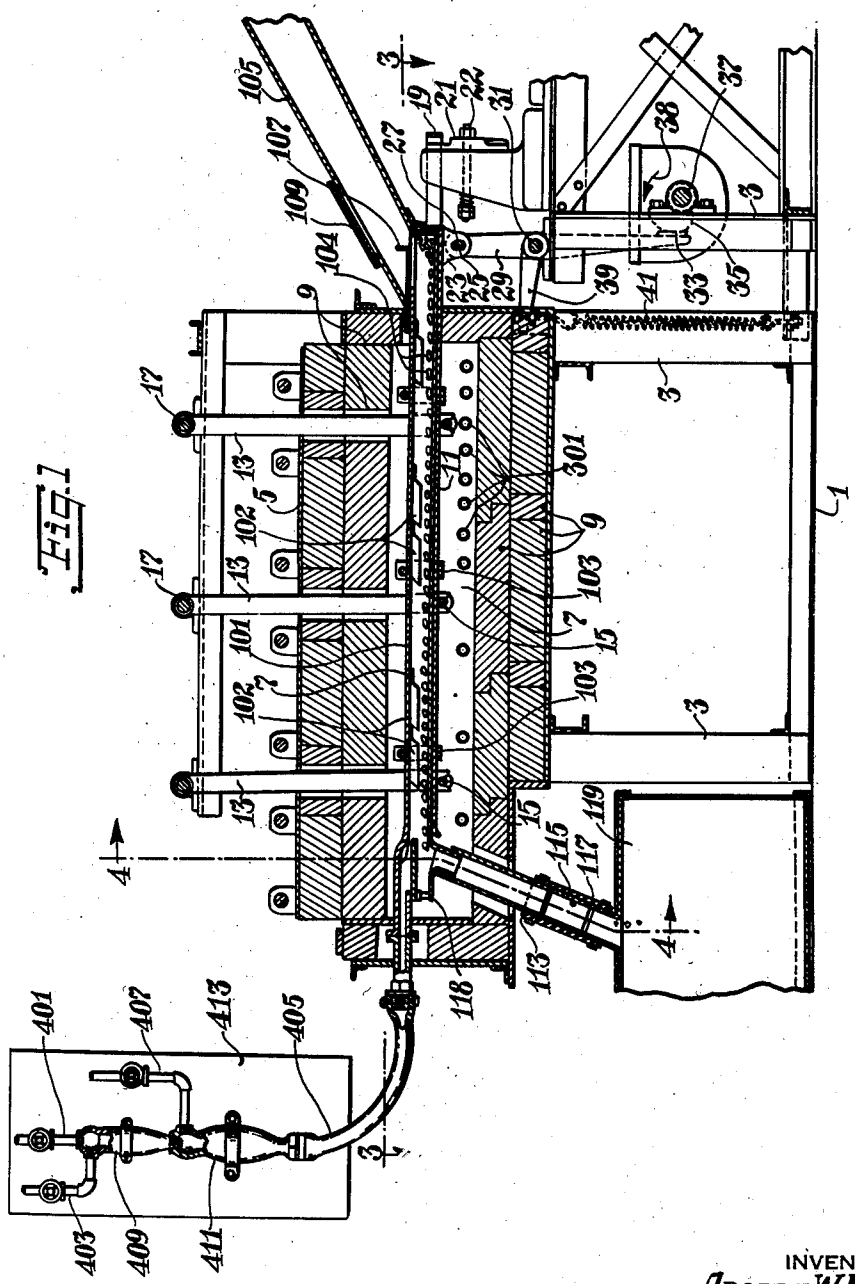
Jan. 23, 1940. A. W. MACHLET 2,188,226

METHOD OF CASING FERROUS ARTICLES

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Fig. 4

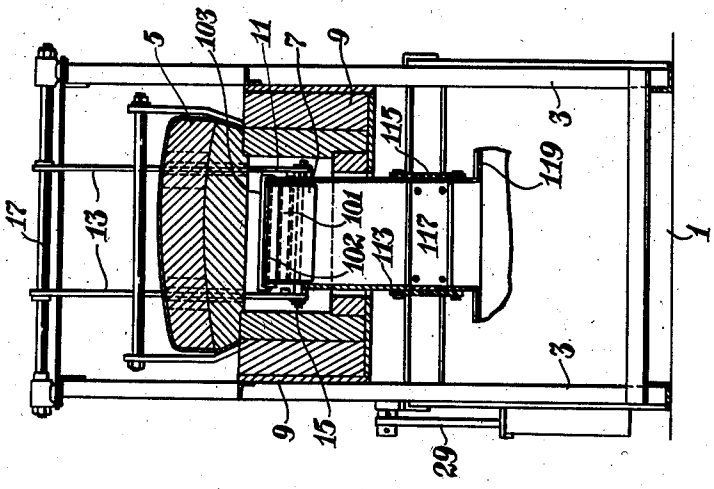


Fig. 3

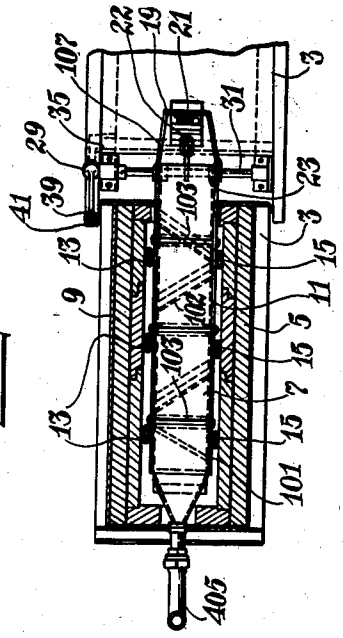
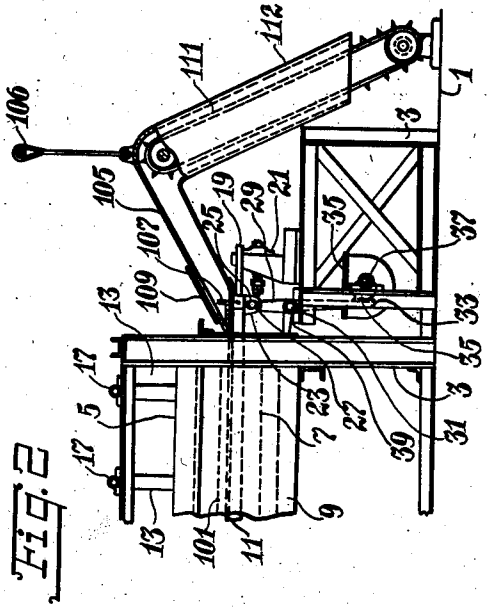


Fig. 2



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Patented Jan. 23, 1940 2,188,226

UNITED STATES PATENT OFFICE

2,188,226

METHOD OF CASING FERROUS ARTICLES

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Application February 24, 1938, Serial No. 192,222

7 Claims. (Cl. 148—16)

This invention pertains to methods, processes or cycles of operation for case hardening or heat treating metals, frequently referred to as the "work," such as ferrous articles, including particularly those made of iron, steel, alloy steels, and alloys having a large iron content.

A broad object of my invention is to provide an improved method, process and/or cycle of operation, for case hardening work, whereby a satisfactory product can be produced at low cost.

Another broad object is to provide an improved method to temper work, after quenching, which consists of applying relatively low temperature case hardening, to such work. Said tempering method may be, except that it is performed at a lower temperature, substantially the same as the method of case hardening described herein. This method of tempering is especially suited to be combined with my improved case hardening method used in the casing operation. It may preferably be like the particular type of case hardening operation below described, so that during the tempering operation there will be added, theoretically at least, a small additional amount of nitrogenized and carburized case, on the surface of the work. Also, no impairment in the case can occur in this tempering operation. The quenching of case hardened work sometimes makes the core of the work so hard that it becomes brittle and one of the advantages of this method of tempering is to cure such core brittleness. Briefly stated, the combined sequence of operations is case hardening in the first pass or processing, quenching, and additional case hardening and tempering, in the second pass or processing.

Another broad object is to provide an improved method to accelerate the production of carburized work and to increase the depth of the case, by the use of a case hardening atmosphere, which includes both carburizing gas and hydrogen bearing gas, such for instance as ammonia, at a temperature of about 1600° F., or more. This kind of an atmosphere, when the case hardening operation is carried on at a graduated temperature, as will be subsequently described in detail, of, for instance, 1600° F. at the beginning and 1300° F. at the end of the casing operation, produces a case on the work which includes both substantial carbon and nitrogen contents. The result is different with a continuous higher temperature, at which carburizing at a fast rate and to a great depth occurs. At such a high temperature little evidence of hard nitriding shows itself in the complete case. At this high temperature of from about 1600° F. up, the gas with a high hydrogen content, such as ammonia appears to act as a carrier into the work for the carbon. Perhaps the ammonia or its hydrogen content, or possibly its nitrogen content, acts as a catalyst or as a flux, to clean the pores of the work, so that the carbon can enter the work more perfectly. One thing that has been especially noted is the reduction of the carbon deposit and coating on the outside of the work in the retort so that the work comes out clean. When the work is quenched, such a deposit, if present, impairs the uniformity of hardness. Also such a deposit makes gauging difficult, and must be carefully removed, where close fits are required. This is an important convenience and advantage, so much so in fact that it substantially extends the usefulness of cased work, particularly carburized work where thick and economically formed cases are required. The work, when thus treated, is produced in a mildly hardened condition and often requires quenching and tempering. The surface hardness is, in this case, much less than when the casing operation has included a final treatment at 1300° F. in a similar case hardening atmosphere.

A more specific object is to apply such improvements to continuous operation, in addition to conventional batch operation.

A still more specific object is to provide a method in which a batch or, in the preferred embodiment of my method, a succession of articles are first heated to a carburizing temperature, carburized, the temperature lowered so as to permit nitriding without the formation of a too coarse crystaline structure in the case and the articles then nitrided. It may be observed that for this combination case, there are temperatures at which carburizing and nitriding are each best practised. However, both tend to blend into each other and there is no sharp line of separation. Suitable temperatures are 1600° F. and 1300° F., respectively, and the combination of gases put in may be substantially the same throughout the operation.

A specific object appears from the preferred embodiment of my method, below described, which includes a particular mode of introducing gaseous treating materials, suitably diluted as required, for both nitriding and carburizing, into the exit end of a vibratory retort. The treating gas being introduced in such a manner that the articles are first substantially carburized at about 1600° F. at the entrance end of the retort and subsequently substantially nitrided at about 1300°

F. at the exit end thereof. The heat first cracks the nitriding gas and liberates nascent nitrogen for nitriding the work at the exit end. The remainder of the gas then flows toward the higher temperature entrance end of the retort and there carburizes the articles. In this specific method a case hardened surface containing a combination of nitrogenized and carburized material, of a hardness which gradually increases as the surface is approached, is formed on work, which may be, for instance, a succession of articles, as they are fed through the retort, or sometimes a single continuous article like a wire or chain.

Another specific object is to, in some cases, where required, quench and harden the work, after said continuous casing operation according to the above mentioned method. The work then being repassed through said preferred embodiment of my method, using lower temperatures, whereby the hardened work is cleanly tempered. Also, usually, a little more case is applied to said tempered work during this second passage.

Still other objects may appear from the following detailed description of the preferred apparatus in which my method or process may be practised.

The present application is a continuation in part of my application Serial No. 732,580 for Methods of continuous heat treating, filed June 27, 1934, allowed April 3, 1937, and forfeited.

The apparatus described hereafter illustrates one type of device in which my method may be practised. However, other forms of both the batch type and the continuous type conventional apparatus, when operated in accordance with the teachings, and the claims, hereof, may also be, in some cases, effectively used. Also, the carbon and other treating materials, for instance hydrogen and nitrogen, may be introduced, if desired, in solid powder or liquid form, sometimes combined with other substances, all of which are well known equivalents in this art. However, I have found gases most convenient and have therefore included them in the detailed description of my method which follows:

Referring to the accompanying drawings:

Fig. 1 is a longitudinal elevation, partly in vertical section of the body and left hand end of my improved continuous heat treating machine.

Fig. 2 is a similar elevation of the right hand end of the device of Fig. 1. However, in Fig. 2 the fragment of the body which is shown appears in full whereas it is in section in Fig. 1.

Fig. 3 is a horizontal section taken on the line 3—3 of Fig. 1.

Fig. 4 is a substantially vertical section taken on the line 4—4 of Fig. 1.

The numeral 1 indicates a floor upon which is mounted a conventional frame 3, supporting a furnace 5, provided with a hot chamber 7, which may be heated by any approved means. For instance, the burners 301 of Fig. 1. It may be noted that there are many more of these burners at the right hand or entrance end of chamber 7 than at the left or exit end thereof. This is to heat the entrance end to a carburizing temperature while only a nitriding temperature is provided at the exit end. The larger number of burners at the entrance end may be dispensed with in a furnace having evenly distributed burners if these are adjusted so as to create a carburizing temperature at the entrance end and nitriding temperature at the exit end. Speaking generally, the nitriding temperature of the articles may be 1300° F. and carburizing temperature 1600° F. Chamber 7 is surrounded by brick insulation 9, secured in a place in a conventional manner, and is of much greater length than height or breadth. Chamber 7 contains a conventional oscillation refractory-metal, trough-like shelf 11 suspended by links 13 depending from the upper part of frame 3.

As shown best in Fig. 1, pivot pins 15 and 17 in cooperation with links 13 permit shelf 11 to oscillate a short distance both to the right and to the left from the indicated position.

Shelf 11 projects through an opening at the right hand end of chamber 7 and is provided, at the extension, with an iron strap 19 which, in the indicated position, is shown as loosely looped around an adjustable bumper 21, of conventional type.

Shelf 11 is also provided with lugs 23 having a hole which contains a pivot pin 25. Pin 25 passes loosely through an oval hole 27 in the upper end of a rocker arm 29. The central portion of rocker arm 29 is pivoted at a shaft 31, which is journaled at frame 3.

Rocker arm 29 extends down from shaft 31 and terminates in a striking plate 33. In the position of Fig. 1 plate 33 engages a cam 35 which is tightly mounted on a shaft 37. Cam 35 and shaft 37 are designed to be rotated in the direction of arrow 38 by power, from any suitable source, not shown.

Upon shaft 31 there is tightly secured a lever arm 39, at the end of which is attached a tension spring 41, designed to transmit torque through shaft 31 and rocker arm 29 to striking plate 33 and force it into contact with cam 35.

Thus member 11 moves from the position of Fig. 1, to the right as shaft 37 is rotated 90°. At 90° member 35 disengages member 33. As soon as the disengagement occurs spring 41, acting through members 39, 29, 25, etc., moves member 11 to the left until the movement is abruptly halted by member 19 striking against member 21.

Member 11 carries a duct-like retort of sheet metal 101, which will be subsequently described in detail. Retort 101 is rigidly but detachably secured to member 11 by strap clamps 103. When member 19 strikes member 21, any work, for instance, the iron objects 104 which are shown as loosely resting in retort 101, slip, because of their momentum, a short distance to the left until brought to rest by friction with the bottom of member 101.

Upon a 180° further rotation of shaft 37, that is to say 270° beyond the position shown in Fig. 1, members 33 and 35 again engage. Members 11, 101 and 104 are then again gradually moved to the right and the cycle is repeated.

Bumper 21 is rotatably mounted on a spring-maintained bolt 22, so that it may be adjusted by the operator to vary the unrestrained movement of members 29, 25, 11, 101, etc., as above described, thus varying the violence of the bumps between members 19 and 21 and controlling the average speed at which the work 104 travels to the left.

The net result of the above described movement is that the work 104 moves slowly toward the left by a succession of short steps. The mechanism may be termed an oscillating or reciprocating conveyor mechanism to distinguish it from the many well-known types of belt conveyors.

Referring to the right of Fig. 2, a chute 105, movably suspended at 106, is shown as attached to member 11. A continuous stream of work may be loaded into the retort 101 from chute 105. Retort 101 is provided with a sliding door 107, and

chute 105 is provided with a sliding inspection door 109. Chute 105 is loaded from a belt conveyor 111, shown in Fig. 2, which is completely enclosed at 112 to a level considerably below the bottom of retort 101, so that treating gases which, because they are usually of lower specific gravity than air, will thus be prevented from leaking out of the retort 101. Door 107 is designed to completely close the right hand end of retort 101 when required, for instance, if the chute 105 is not in use. In such an event the work may be fed in through door 107 by hand.

The left hand end of retort 101 is provided with a down spout 113 having a flexible portion 115 preferably provided with a suitable heat-resisting lining 117. A sliding door 118 at the left hand end of retort 101 is provided to permit the cleaning out of the retort 101 when required. The lower end of down spout 113 is shown as discharging into a closed tank or box 119 where the work may be gradually accumulated after passing through retort 101. Tank 119 may contain oil or water if it is desired to immediately quench the work after it has passed through retort 101 as above described.

It may be observed that both the bottom of down spout 113 and housing 112 are below retort 101 so that we have in effect a bell like closure or hood for treating gases, which will prevent their wastage.

The treating materials may be either in the form of solids, powder, liquid or gas, but treating materials in gaseous form are generally used, and the fittings at the left of retort 101 are particularly arranged for the introduction of gaseous treating materials into retort 101.

The method of treating work, usually small ferrous articles, in the above described apparatus, although a continuous article like a wire or chain might also be treated, consists of combined carburizing at a retort temperature of 1600° F. followed by nitriding at 1300° F. Suitable treating materials include any hydrocarbon gas, which may enter through a pipe 401, and ammonia gas, which may enter through a pipe 403. Pipes 401 and 403 communicate through a hose or flexible pipe 405 with the left hand end of retort 101. In addition to the gases entering through pipes 401 and 403 a diluent, such, for instance as air, may be introduced through a pipe 407. Usually one of the gases is available at a higher pressure than the others. In the arrangement just described, the higher pressure gas is assumed to enter through pipe 401, which injects the lower pressure gas from pipe 403, at an injector 409. The combined stream then injects the gas (air) from pipe 407, at injector 411, into pipe 405. Members 409 and 411 are mounted on a panel 413.

Retort 101 is stiffened at its upper portion by diagonal braces 102, and these braces also act as baffles for the even distribution of the treating gases as they flow toward the right through the retort 101. By introducing the articles to be case hardened at the high temperature entrance end at the right of Fig. 1, there carburizing same, permiting the temperature to become lower as the work travels to the left and then nitriding same, heat and treating material are both economized. It is desirable that both nitriding and carburizing gases enter together at the left, as above described, so that a perfect blend of nitriding and carburizing may be had and the nitriding performed at a low enough temperature to avoid a coarse grain in the case.

With the above described combination of apparatus and method, some small ferrous articles can be hardened sufficiently for most practical purposes, at very low cost, in about five minutes of actual processing in the retort 101. The articles are discharged from the retort 101 ready for use as soon as they cool off. In some cases the tank or box 119 may be filled with water, preferably maintained automatically at some predetermined temperature and the work automatically quenched therein. However, the combined carburized and nitrided finish alone is frequently hard enough and satisfactory, without quenching.

The apparatus and method above described is particularly designed to perform the same type of hardening of ferrous articles which is now usually effected in cyaniding furnaces and to accomplish this work without any danger to the health of the operator, such as is always present when cyanide is used.

Such a surface need not be very thick and by combining the carburizing and nitrogenizing treating materials, as above described, a coating of adequate hardness, which requires no tempering, as does a carburized case, may be produced as a continuous operation, by the above described apparatus and method.

Such case work may also be quenched and then tempered in a substantially similar atmosphere, by lowering the temperature of the retort, and passing the work through it a second time; then allowing the work to cool normally and without quenching. This treatment will prevent the core of the work being brittle and is sometimes desirable. It also will, theoretically at least, add a little more thickness to the case and of course prevents any impairment of the surface of the work.

By maintaining the retort temperature at 1600° F., or perhaps at a higher heat of, for instance, 1650° F., throughout its entire length, the nitriding effect largely disappears but very rapid and deep carburizing occurs. This is believed to be due to the ammonia cracking and the nascent nitrogen becoming free and less chemically active, before contacting the work. One or other of its constituent gases, hydrogen or perhapse nitrogen, then is believed to act as a carrier for the carbon, into the iron. Whatever the explanation may be, the finished work comes out more deeply carburized and freer of troublesome carbon deposit than where carburizing gas alone is used. Work thus carburized should be quenched, and preferably tempered, for cutting tools, etc. The tempering may, if desired, be performed by repassing the work through the retort, as previously described, at a lower temperature.

It is practical to get a good moderately hardened carburized case at 1600° F., or 1650° F., with such a combination atmosphere, but with a lower temperature, such as, for instance, 1500° F., a more or less brittle case, with a coarse grain tends to form. The correct temperature range is thus very important although the analysis of the material and the nature of the work may make some small changes desirable in order to get the optimum temperature.

One of the advantages incidental to the practise of my method in the continuous heat treating machine, above described, is that the vibration of the retort causes the treating gas and the work to be churned around so that all surfaces of the work tend to be more rapidly and uniformly heat treated.

In this specification, my method has been discussed particularly with relation to the preferred manner in which I practice it in a continuous heat treating machine. However, the method in its broader forms may be practised in the conventional batch type of carburizing machines, which are well known in the art. When my method is practised in such batch type carburizing machines, economies may be effected for some types of work, but for many purposes my method may be practised equally well in either batch type or continuous heat treating machines.

I do not limit myself to the exact construction or method shown and described above, which may be modified in accordance with progress of the art, and the scope of my invention will be pointed out in the following claims.

The expression closed retort in the specification and claims is intended to mean a retort sufficiently gas tight to avoid excessive waste of the treating gas.

I claim:

1. The process of hardening ferrous articles in the presence of heat, which consists of advancing a succession of such articles under suitable temperature conditions, through case hardening material including both carburizing and nitriding substances, while confined in an enclosure and causing said substances to move in a direction opposite the advancing work, the temperature decreasing as the work advances.

2. The herein described method of case hardening which includes the steps of providing and maintaining an atmosphere of carburizing and nitriding gases, feeding a plurality of articles successively into one end portion of said atmosphere, then successively through an intermediate portion of said atmosphere, and then successively out of an opposite end portion of said atmosphere in a substantially continuous succession, maintaining at a carburizing temperature of substantially 1600° F. a predetermined portion of the atmosphere through which the articles enter and pass along their path of travel and maintaining at a nitriding temperature of substantially 1300° F. a predetermined portion of the atmosphere through which the articles continue to travel and from which they pass out of said opposite end portion of the atmosphere.

3. The herein described method of case hardening which includes the steps of introducing carburizing and nitriding gases into a closed retort, feeding a plurality of articles successively into one end of the retort into and through the atmosphere and out of the opposite end of the retort, maintaining a carburizing temperature of substantially 1600° F. throughout an initial portion of the travel of the articles through the atmosphere, maintaining a nitriding temperature of substantially 1300° F. throughout a final portion of the travel of the articles through the atmosphere, and continuing the supplying of carburizing and nitriding gases as required.

4. The herein described method of case hardening, which includes the steps of providing an atmosphere containing carburizing and nitriding gases, feeding articles into, through and out of said case hardening atmosphere, subjecting the articles in an initial path of travel through said case hardening atmosphere to a carburizing temperature, progressively decreasing the temperature at which the articles are subjected in their path of travel subsequent to said initial path of travel to a nitriding temperature, and discharging the articles in a case hardened condition from the case hardening atmosphere.

5. The process of hardening ferrous articles in the presence of heat, which consists of advancing a succession of such articles, under suitable temperature conditions, through case-hardening material including both carburizing and nitriding substances, which is progressively changing in quality, decreasing the temperature as the richness of the case-hardening material increases, and causing said material to move in the opposite direction to the articles.

6. The process of hardening ferrous articles in the presence of heat, which consists in advancing a succession of such articles, under suitable temperature conditions, through case-hardening material including both carburizing and nitriding substances, which is progressively changing in quality, decreasing the heat as the work progresses and the work is successively carburized and nitrided, and causing said material to move in the opposite direction to the articles.

7. The herein described method of case-hardening which includes the steps of providing an atmosphere including carburizing and nitriding properties, feeding an article into, through and out of said atmosphere, subjecting the article and the atmosphere to a carburizing temperature along an initial portion of the travel of the article through said atmosphere and thereby carburizing the article, subjecting the article and the atmosphere to a nitriding temperature along a final portion of the travel of the article and thereby nitriding the carburized article, progressively decreasing the temperature along the intermediate portion of travel of the article from the carburizing temperature to the nitriding temperature while continuing to subject the article to said atmosphere and thereby merging carburization into nitriding, and flowing said atmosphere across the article in a direction opposite to that of the travel of the article.

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