

Aug. 23, 1966

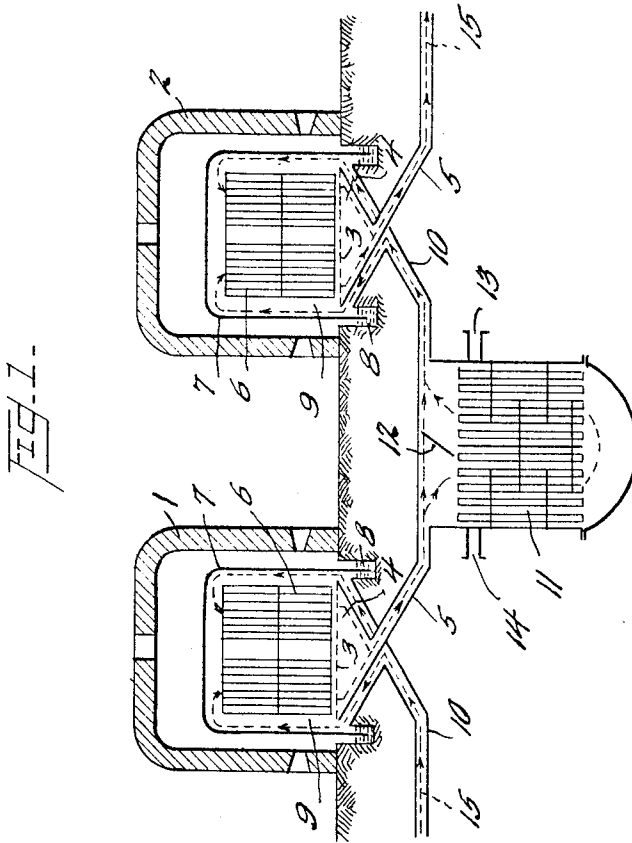
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PROCESS AND APPARATUS FOR ANNEALING METAL PLATES

Filed March 11, 1965

2 Sheets-Sheet 1



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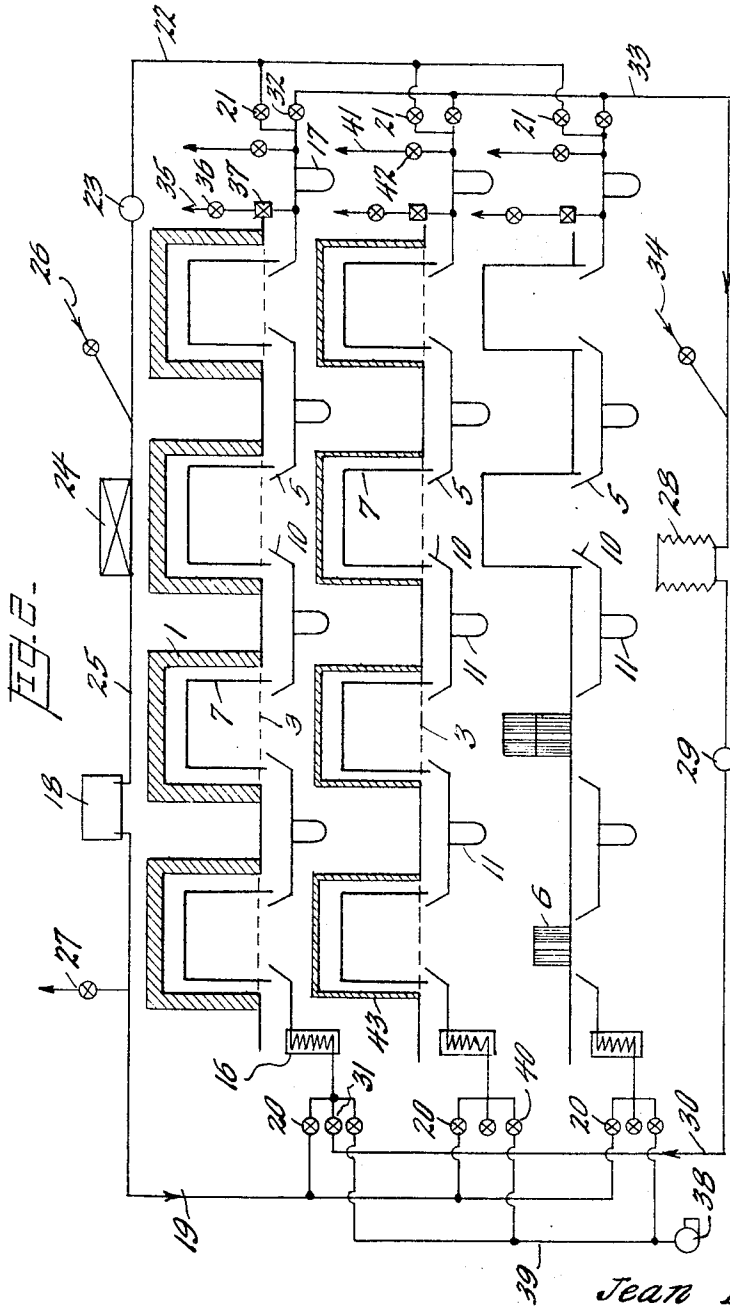
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PROCESS AND APPARATUS FOR ANNEALING METAL PLATES

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Filed Mar. 11, 1965, Ser. No. 444,894

Claims priority, application Belgium, Mar. 7, 1961,

38,977, Patent 601,043

3 Claims. (Cl. 148—16)

This application is a continuation-in-part of the co-pending application filed March 6, 1962, Serial No. 177,877, now abandoned.

The present invention relates to a process and apparatus for annealing soft steel plates in moist hydrogen.

The possibility of extracting carbon and nitrogen from steel sheets by annealing by moist hydrogen is well known. It has likewise been known for a long time that it is possible in extracting by this treatment, the last traces of carbon and nitrogen from a sheet of rimming steel to render this sheet insensitive to aging. Numerous theoretical and experimental studies have been made on this subject, and more specifically a very complete study was made by S. W. Low and H. Gensamer (Metals Technology, December 1943), as well as U.S. Patent No. 2,360,768, by Gensamer. However, in spite of the great technical interest of such a process for the drawing industry, it has not been possible to realize any practical application in this field, the cost of such an annealing operation being prohibitive as compared with the market value of a sheet of good drawing quality. In addition to the great expense for hydrogen necessary for the realization of the decarburization and denitrification one had to reckon with the very slight productive capacity of the continuous annealing furnaces which had to be installed instead of bell furnaces in order to permit the action of the atmosphere's gases on the metal sheet. This slight capacity is of course due to the extreme slowness of the reactions necessitating periods of contact between the sheet and the atmosphere of the order of several hours.

More recently decarbonizing-denitrifying annealing has again aroused the interest of the metal sheet industries owing to the realization of the "open-coil" bell furnace which allows usage of a bell furnace in place of a continuous one (U.S. Patent No. 3,114,539, Lee Wilson and E. A. Corns). Indeed it has become possible to wind coils of metal sheets in unjoined spirals with a precision such that the gas circulating in the bell annealing furnace can pass between the spirals of the coil and act with a sufficient regularity over the entire surface of the sheet so wound.

The technique now recommended consists in using annealing furnaces very similar to the bell furnaces traditionally employed for non-expanded coils and which comprise like these traditional furnaces a hearth provided with a system of internal circulation of the atmosphere's gases (fan).

These furnaces for expanded coils differ practically from the traditional furnaces only by their dimensions and by some details relative to the packings or tight joints.

Their use for a decarburizing-denitrifying annealing operation comprises in principle a period of heating under a neutral protective gas (such as HNX gas), a period of soaking (maintenance at constant temperature) in an atmosphere of moist H_2 gas and a period of cooling under a protective gas such as dry HNX gas, which is a mixture of N_2 with 5 to 10% H_2 .

So used, these furnaces give after annealing, non-aging steels. However, this result is obtained only by an excessive prolongation of the time of soaking under an atmosphere of moist hydrogen. Denitrifying, even when

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it is a question of steels particularly poor in nitrogen, requires a period of time of the order of 10 to 20 hours. This disadvantage considerably reduces the capacity of production and involves a greater consumption of hydrogen and heating calories.

These results are all the more deceptive because it is possible in the laboratory to render non-aging the same steel sheets by a treatment with moist hydrogen the duration of which does not exceed 3 hours (time cited moreover by Gensamer in the above-mentioned patent).

Decarburization-denitrification tests on a semi-industrial furnace and detailed study of the circulation of the gases realized in the bell furnaces now used for annealing expanded coils have shown to the applicant that these difficulties arose from a bad realization of the circulation of the moist hydrogen atmosphere between the spirals of the coils. The classic system of circulation of the gases used in bell furnaces for coils comprises a fan of the centrifugal type intended to insure the circulation of the gases.

This circulation internal to the furnace comprises the successive flowing of the gases through the turbine, along the heated walls of the bell and through the spirals of the coils, the cycle beginning again endlessly with a flow resulting from the motive power due to the fan and the internal resistance of the circuit. On this internal circulation there is superposed an external circulation comprising the injection in the furnace of a certain quantity of fresh gases and the extraction of an approximately equal volume of gas contaminated by the impurities coming from the chemical reactions which take place in the furnace.

The fan has without doubt an appreciable effect on the time of heating in a relatively dense atmosphere such as HNX gas (more than 90% of N_2) but when the gases become heated and especially when the protective atmosphere is replaced by moist hydrogen considerably lighter and carried to temperatures of the order of 700° C. the flows shut down considerably. In fact, it has been noted that the flow circulating in the coils, measured in standard cubic meters, was in the period of soaking with moist hydrogen reduced to less than $\frac{1}{100}$ of the flow of gas realized at the beginning of the heating under HNX gas.

Furthermore, and this is without doubt still more serious, the presence of a fan is an impediment to the establishment of a sufficient and rational circulation.

In view of the slight motive pressure produced by the fan, it is indeed impossible to create a considerable external circulation and it is evident that it is not possible to introduce a flow of fresh gas exceeding that of the internal circulation for the excess not passed into the spirals of the coils but will be short-circuited through the fan, in inverse direction to the normal direction of circulation.

On the other hand, when the fan delivers on the internal circuit, the fresh gas injected must necessarily be mixed with the contaminated gas in circulation and the high degrees of purity necessary for denitrification are only very slowly attained.

In a prior Belgian patent, No. 600,643, there is already set forth explicitly a solution of these difficulties consisting in obturating the inlet or outlet orifice of the fan during the period of soaking with moist hydrogen.

The present application describes and claims as solution to the same problem a much more general process of less costly operation and a much more simple apparatus.

The process is characterized in that expanded coils are introduced into several furnaces and subjected simultaneously to successive operations of heating under protective atmosphere (HNX), of soaking under moist hydrogen and cooling under protective atmosphere (HNX) in

that the atmosphere's gases effect a simple travel through each furnace and its charge (that is to say without superposition of an internal circulation by fan), in that during the periods of heating and soaking the gases leaving a furnace are recovered and there are used again both their sensible heat and their residual properties as protective agent or as denitrifying-decarburizing agent by returning these gases into another furnace, and in that, during the periods of cooling the gases leaving a furnace are recovered, cooled and sent into another furnace.

The apparatus claimed for carrying out these processes are characterized chiefly by the following features:

(a) The furnaces used have their own system of heating and cooling but have no fan for internal circulation.

(b) They are distributed in groups of several units connected in series insofar as concerns the circuit of gases used as atmosphere, the inlet of a furnace (with the exception of the first of the series) being connected to the furnace which precedes it by a pipe preferably short and well heat insulated in which is inserted a cooler.

(c) The entire outlet pipe of the head furnace-cooler-inlet pipe of the tail furnace connects directly the two furnaces to one another without the intervention of valves, the cooler being simply provided with an internal by-pass valve to the system.

(d) Several groups of furnaces are placed in service and are in principle connected between general pipes admitting fluids and general pipes for evacuation with joints provided with valves and in the inlet pipes there is provided a sufficient pressure as compared with the pressure prevailing in the evacuation pipes to realize the circulation of the gases through the furnaces of each series.

As compared with known installations, the operation of the installations according to the invention offers important economies.

Economy in hydrogen is realized by the fact that this gas passes successively into each of the furnaces. It is quite certain that the last traces of carbon and nitrogen can be extracted from the metal plate only by using a gas very pure from carbon and combined nitrogen, which gas is particularly costly to prepare. However, it is not necessary to use gases so pure from carbon and combined nitrogen at the beginning of the operation when the level of the carbon and nitrogen in the plate is still high. The gases contaminated by their travel through the first furnaces of the group are therefore not inactive in the following furnaces. Gradually the purity of the gases will improve and finally the last furnace will receive a very pure gas able to complete the operation.

The arrangement according to the invention is particularly well adapted to the recovery of the contaminated hydrogen gas, its purification and its recycling by a process already disclosed by the inventor.

Economy in calories results from the fact that the sensible heat carried along by the gases leaving the furnace during the heating and the soaking are used again practically in their entirety in the further furnace. The loss exists only for the last furnace of the group and may still be recovered in part. This allows circulating very high volumes of gas without excessive losses.

Economy in time is obtained during the heating and soaking, resulting from the very high flows of gas which it is possible to force in circulation. As for cooling it is considerably accelerated at the same time by the high flows of gas, the action of the very great cooling surfaces of the coolers to which can be added the action by radiation of the cooling bells.

Economy in investment is important resulting from the considerable simplification of the accessories and particularly suppression of the circulation fans and their motors, and suppression of all valves and flow regulators except at the entrance and outlet of the group. It must not be overlooked that H_2 gas is very dangerous to use and that the requirements of safety entail costly complications to insure the circulation of the different gases and the perfect isolation of the circuits in which the hydrogen

can circulate, especially as the gases leave the furnaces at temperatures which may attain and even exceed $700^\circ C$.

The number of units to be grouped in series is limited on the one hand because the pressures necessary for circulation of the gases in each of the furnaces are added and pose a problem of tightness of the joints and, on the other hand, by the fact that the simultaneous operation of several furnaces breaks the continuity of the rhythm of supplying and emptying the coil annealing plant.

Groups of four or five units of two superposed coils give satisfaction in these two respects, but this is far from being restrictive. In such a group it is possible to circulate 3000 to 7000 cu. m. per hour of HNX gas in a period of heating and cooling without exceeding a total pressure of 1500 mm. of water. In a period of soaking with moist hydrogen, one must not exceed 200 mm. of water for flows of the order of 2000 cu. m. per hour. This gives acceptable operating conditions for the packed joints of the bells and permits reducing annealing time by about 50%.

With a view to further accelerating the heating, it is possible to add to or substitute for the heating by transportable bell furnaces, a heating by a heater of the protective gases, which is interposed between each furnace in the same manner as the cooler; these two devices may even be combined so as to serve alternatively as a heater or as a cooler.

In current practice the annealed coils are uncovered as soon as the temperature has fallen to a level where the oxidation by the air is no longer to be feared and the coils are transported on platforms constructed so as to allow air cooling. In the installations according to the invention which are cheaper and which already have their system of accelerated cooling, it may be worthwhile to avoid the construction of platforms with air cooling and the handling of the coils, to effect the cooling with air on the base of the furnaces. It will be sufficient for that purpose to connect the head furnace to a sufficiently powerful air fan.

Referring now to the drawing, the several views show a number of preferred combinations which will permit a better understanding of the invention.

FIGURE 1 is a vertical cross section partly in diagrammatic outline of a two furnace group, and

FIGURE 2 is a diagrammatic view of three groups of four furnaces.

FIGURE 1 shows two furnaces of a group equipped and connected according to the invention with 1 and 2 representing transportable heating caissons which cover the two furnaces.

Each furnace has a perforated foundation 3 connected in a tight manner by means of a coffer 4 to the outlet pipe line 5 for the protective gases. On this foundation rest the open coils 6. The latter are covered with a bell 7 which isolates them by means of a packed joint 8. The free circular crown 9 between the bell and the coils is connected in a tight manner to the inlet pipe 10 for the protective gases.

Between the two furnaces and connected directly with or without the intermediary of valves there is interposed the cooler 11 provided with an internal flap valve 12. The inlet and the outlet of the cooling fluid are respectively indicated at 13 and 14. The circulation of the protective gases is represented by the broken lines and the arrows 15.

FIG. 2 represents a diagram of an installation illustrating 3 groups of 4 furnaces, the first group being represented as for heating, the second group as cooling and the third group for discharging or charging. Each furnace or base is shown on its foundation 3, the different elements being marked with the same numerals as in FIG. 1. Each group has in front of the head furnace a gas heater 16 and at the back of the last furnace of the group a gas cooler 17.

The feeding of H_2 gas is effected under the operating pressure of the gasholder 18 with the aid of a pipe 19

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and valves 20. The hydrogen gas circulates in series in each of the furnaces of the group, is cooled in the cooler 17 and recovered by the circuit comprising the valve 21, the pipe 22, the compressor 23, the purifier 24 which frees it from the CO impurities and the combined nitrogen; the gas thus returning to the gas holder through the conduit 25. The feeding with fresh hydrogen is effected at 26 and the cleaning at 27.

The feeding of HNX is effected under the motive pressure of the gas holder 28 and of the compressor 29 through the pipe 30 and the valves 31. The gas HNX can be recovered in the gas holder 28 by the circuit comprising the valves 32 and the conduit 33. The addition of fresh HNX is effected at 34. The purges of HNX gas contaminated by oil vapor at the beginning of the heating are effected through the pipe 33 provided with valves 36 and oil extractors 37.

For cooling by air, starting with temperatures low enough as to avoid any danger of oxidation, there are utilized the fan 38, the pipe 39, the valves 40, the exhaust being effected through the pipe 41 and the valve 42.

The numeral 43 indicates the cooling bells. In order to simplify the diagram the moistening of the hydrogen has not been shown; it may be carried out by known means once for all for the series of furnaces.

The operation of annealing is carried out as follows:

During the charging and discharging of the furnaces of a group (illustrated by the group at the bottom of FIG. 2) it is sufficient to close the principal valves 20, 31, 40 and 21, 32 at the entrance and outlet of the group in order to be able to work in full security. It is sufficient, indeed, for the valves 20 and 21, which are used for cold hydrogen, at relatively slight pressure, to be tight. Such valves are available as commercial units.

The gases being charged, covered with their packing bell and the heating caisson (represented by the group at the top of FIG. 2), one proceeds with a first circulation of the HNX gas by opening valves 31 and 36 and one puts all the furnaces of the group into service as well as the heaters 16. As well as the temperature rises, the oil vapors are evolving and escape at 35. When the gases escaping at 35 are sufficiently pure from oil vapor they may be recovered by opening valve 32 and closing valve 36 after having placed the cooler 17 in service.

In order to begin the soaking with moist H_2 it will be sufficient to close valve 32 and open valve 36, close valve 31 and open valve 20. The atmosphere is purged through line 35.

When the proportion of nitrogen has fallen sufficiently in the gas escaping at 35, one may recover H_2 by opening valve 21 and closing valve 36, the compressor 23 and the purification station 24 being put into service.

For all these operations which are conducted at high temperature, the intermediate coolers are placed out of service by the appropriate manipulation of the short circuit flap valve and/or the cutting off of the cooling fluid.

In order to proceed with the cooling, the heating

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furnaces are withdrawn and they are replaced by the cooling bells (middle group of FIG. 2) and the intermediate coolers are put into service. The replacement of the H_2 gas by HNX gas is effected at the opportune time by manipulations analogous to those already described for the reverse change. When the temperature is low enough one replaces by analogous manipulation, the HNX by a more important circulation of air after having actuated the fan 38. The air is allowed to escape at the outlet through the valve 42 and the pipe 41.

I claim:

1. Process for the decarburization and denitrification of steel sheets annealed in expanded coils under a bell by moist hydrogen, comprising introducing the expanded coils into a plurality of bell-shaped furnaces, subjecting simultaneously all the coils to the successive operation of heating at 680° – 750° C. under a protective atmosphere of pure nitrogen with an addition of 5 to 10% hydrogen, soaking in moist atmosphere of hydrogen at a maximum of 35% water vapor and cooling under the protective atmosphere, the treating gases of said atmospheres effecting a single travel through each furnace and its charge from one to the other with no forced internal circulation, the respective heating and soaking steps being carried out with the gases leaving one furnace being directed into a succeeding furnace for recovering and using again their sensible heat and their residual properties as protective agent and as denitrification and decarburization agent, whereas during the cooling step the gases in one furnace being cooled and again used as cooling agent in a following furnace of the series, the flow of the moist hydrogen during the soaking period being in the order of $2,000\text{ m}^3/\text{h.}$, and the flow of protective atmosphere being between $3,000$ and $7,000\text{ m}^3/\text{h.}$ during cooling.

2. A process according to claim 1, in which hydrogen is provided as the protective atmosphere.

3. A process according to claim 1, in which the final cooling step is effected by blowing air as the protective gas through the furnace and cooler connected in series.

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