TABLE 4*

Material	Interaction time, hrs	Nature and thickness of layer, mm	Loss of cross-sectional area, %	$FeZn_7$ content in zinc, %
TPI	2	$FeZn_7 - 0,2$ locally, $\alpha\text{-Fe(Si)} - 0,1$	1,5	In some places base metal touched by $FeZn_7$, in others by $\alpha\text{-Fe(Si)}$. In nickel, 20% $FeZn_7$
Same	5	$FeZn_7 - 0,4$	4	In zinc, 30% $FeZn_7$
"	10	$FeZn_7 - 0,5$	6	In zinc, 40% $FeZn_7$
Steel 30	2	$FeZn_7 - 0,35$	1,5	In zinc, 25% $FeZn_7$
Same	5	$FeZn_7 - 0,45$	5	In zinc, 30% $FeZn_7$
"	10	$FeZn_7 - 0,6$	8	In zinc, 40% $FeZn_7$
Steel 50	2	$FeZn_7 - 0,1$ and $\alpha\text{-Fe(Si)} - 0,1$	3	Locally, $FeZn_7$ in others by $\alpha\text{-Fe(Si)}$, in zinc, 20% $FeZn_7$
Same	5	$FeZn_7 - 0,4$	5	In zinc, 25% $FeZn_7$
"	10	$FeZn_7 - 0,9$	10	In zinc, 40% $FeZn_7$
Steel U10A	2	Locally, $FeZn_7 - 0,15$ Locally, $\alpha\text{-Fe(Si)} - 0,15$	6	In zinc, 40% $FeZn_7$
Same	5	$FeZn_7 - 1,0$	12	In zinc, 50% $FeZn_7$
"	10	$FeZn_7 - 2,5$	22	In zinc, 70% $FeZn_7$

Interaction of specimens with molten zinc at 500°C after siliconizing at 850°C/2 hrs.

*All commas are equivalent to a decimal point.

similar treatment of steels with 0.5 and 1% C increases their resistance to solubility. In a steel with 0.5% C, localized dissolution centers are found only after a substantial time has elapsed while in steel with 1% C there is no trace of dissolution in molten zinc ever after very long immersion periods.

4. The differential effect of chromium impregnation on solubility in molten zinc of steels with various carbon contents is attributable to different compositions of the alloy phases resulting from impregnation.

5. Electrolytic chromium plating of iron and steel has no proective effect insofar as attack by liquid zinc is concerned.

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NITRIDING OF STEEL UNDER ULTRASONIC VIBRATIONS

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We have studied the nitriding of steel in gaseous and liquid media under ultrasonic vibrations.

Dry Nitriding. Specimens were prepared from steel 35KhYuA treated to R_C 28-30. Prior to nitriding the specimens were screwed into a concentrator and carefully cleaned with alcohol. To prevent oxidation, ammonia was fed into the furnace above 200°C. The degree of ammonia dissociation during nitriding (500-550°C) was 40%. The specimen was finally cooled to 200°C in ammonia. The process was conducted with and without the use of ultrasonics.

Liquid Nitriding was carried out in a salt bath ($CaCl_2$ - 48%, $BaCl_2$ - 31%, NaCl - 21%) with ammonia bubbled through it. The ultrasonic vibrations were transmitted to the liquid bath through the concentrator. The
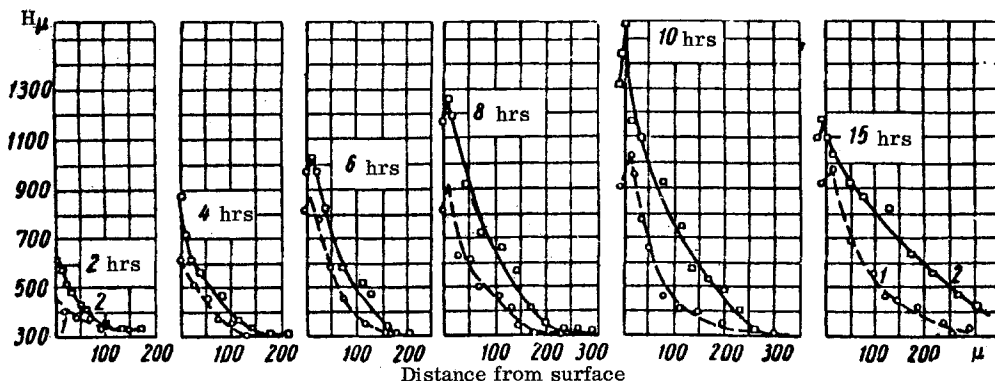
Fig. 1. Effect of ultrasound on microhardness distribution across the depth
of a nitrided case (550°C):
1 — without. 2 — with ultrasonic vibrations.

process was conducted at 550-560°C/9 hrs., at an ammonia pressure of 330-360 mm of oil. High-frequency electric vibrations were produced by a 2.5 kw tube generator at a frequency 18-35 kc p.s. A Permendur magnetostrictive vibrator was used to transform the electric vibrations into acoustic ones.
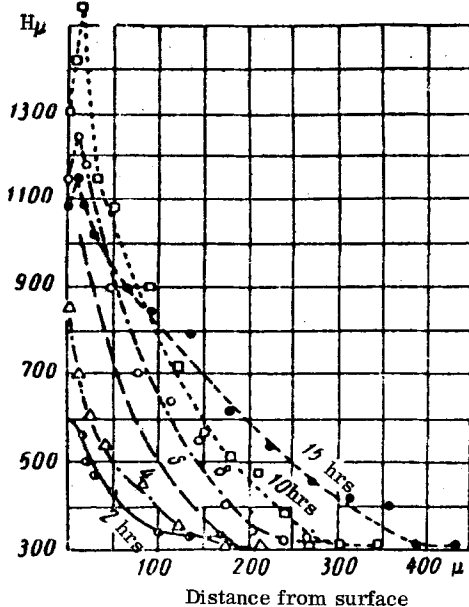

Fig. 2. Microhardness changes over the
nitrided case obtained under ultrasonics
(550°C).

The nitriding results were assessed from Vickers hardness tests on the surface (5 kg load) and microhardness tests across the case thickness on a PMT-3 instrument with a 50 g load.

The microhardness data obtained after various holding times in the gaseous medium are shown in Figures 1-2. Ultrasound increased the hardness and the depth of nitrogen penetration and secured a stable improvement of the microhardness in the main zone of the nitrited case. After soaking for six hrs. or more, the microhardness of the ultrasonically treated specimens was much higher than without such treat-

ment. After 15 hrs. the microhardness of the case decreased when compared with 8 and 10 hrs.; however, the microhardness of the central layer of the nitrided case increased. Using ultrasonics, the treatment time was reduced 1.5 times.

The microhardness change from the surface to the center of the case as obtained by liquid nitriding with and without ultrasonics is given in Figure 3. A comparison of the results of gas and liquid processes revelaed deeper penetration and higher hardness in gas nitriding, i.e., when the specimen is excited directly.
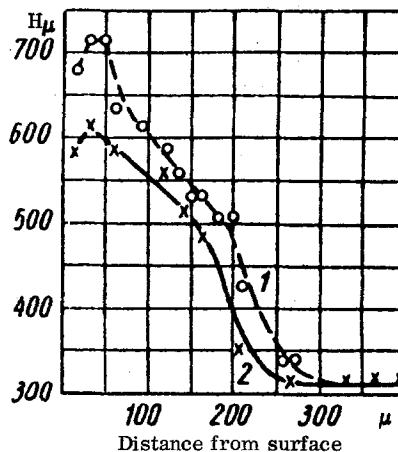

Fig. 3. Microhardness changes over the
case depth after nitriding in a liquid bath:

1 — with. 2 — without ultrasonics.

The advantages of an ultrasonic treatment can be explained by periodical changes of the lattice constants and by an increased amplitude of thermal vibration of ions from to localized temperature rises. To make a nitrogen ion jump into a new position in an interstitial solid solution, one must await for a definite coincidence between the vibration phases of the nitrogen ion and the nearest iron ions. Apparently this occurs more often at the high frequency of ion vibration in the lattice when ultrasound is ultrasound.

The ultrasonic vibration also facilitates the removal of reaction products from the metal surface and a continuous supply of fresh gas; This increases the chemical interaction rate and accelerates dissolution thereby increasing the nitrogen concentration in the metal surface. Further, it is possible that ultrasonic vibration produces ultramicroscopic pores in the metal. This would increase the surface energy and facilitate the adsorption of surface-active elements.

The advantageous effect of ultrasonics on the microhardness and penetration depth of nitrogen was also observed at 500°C.

Metallographic observations showed that no nitrided case could be seen after holding for two hrs. and that it became visible only after at least four hrs. Visual observations indicates a thinner nitrided case than would appear from microhardness measurements. The central zone of the nitrided case responded better to etching after the specimens had been exposed to ultrasonics for six hrs. or more. Irrespective of the nitriding procedure, we found no embrittlement of the nitrided case. Hence, the work showed that both the case depth and the hardness of the nitrided case improved underultrasonic vibrations.

TRANSFORMATION OF RETAINED AUSTENITE
IN CARBURIZING STEELS

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This work deals with the transformation kinetics of retained austenite immediately after carburizing and also after quenching of carburizing steels 12KhN3A (steel "A"), 12Kh2N4 (steel "B"), 18KhNVA ("C"), 18KhNT ("D") and 20KhGR ("E"). In addition, we have studied the effect of tempering prior to quenching on the amount of retained austenite and the effect of sub-zero treatment. Specimens 4 mm dia. and 40 mm long were pack-carburized in a mixture of 60% wood charcoal and 40% barium carbonate at 940°C for 0.5, 1, 3 and 6 hrs. A magnetic analysis was performed on ballistic and dipol magnetometers.

Transformation of Retained Austenite in Carburized Specimens. Magnetometric tests on specimens prior to and after carburizing showed a decrease of the (intensity of) magnetization in all cases, the effect increasing with carburizing time. It was particularly large for steels A, C and B.

In steels E and D, the fall of magnetization was due to carbide formation. In the other three, it was caused essentially by austenite retained after carburizing. We were concerned with the transformation of austenite during slow heating as well as during isothermal tempering of our specimens.

The analysis of the transformation during slow heating (5°C/min) was conducted from the curves of magnetization changes of the specimens with temperature, $J_S(t)$, Figures 1 and 2.

In specimens A carburized for 30 min, the decomposition of austenite occurred at 250-400°C and terminated during the heating stage. This indicates reversibility of the curves during cooling and repeated heating, Figure 1, curve 1. In specimens carburized for 6 hrs., most of the austenite decomposed also during heating to 400°C and a minor fraction during cooling, Figure 1, curve 2. A part of the retained austenite in steels B and C decomposed during cooling after heating to 500-650°C, Figure 2. The longer the carburizing time, the more austenite decomposed during cooling.
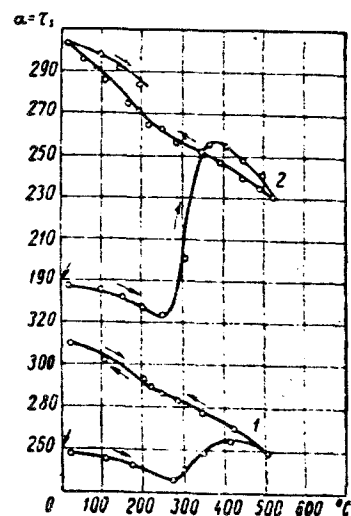

Fig. 1. Change of magnetization during heating, cooling and second heating of carburized steel A.

Carburizing time: 1 — 30 min; 2 — 6 hrs.

Apparently, the carburized specimens contain two types of austenite. The unstable variety is located near the core and decomposes during heating; the more stable one is located in the surface layer. The decomposition of the second kind occurs only during cooling after heating to a high temperature. With increasing carburizing time, the carbon penetrates deeper and deeper and this is why