MOROZ, L. M.

= The first prize of 10,000 roubles(imeni D. K. Chernov) was awarded to the following team: Professor S. Z. Bokshteyn, Engineer T. I. Gudkova, Doctor of Technical Sciences Professor A. A. Zhukhovitskiy, Doctor of Technical Sciences Professor S. T. Kishkin and Engineer L. M. Moroz for the paper "Investigation of the diffusion and the distribution of components in a real metal by means of radioactive tracers". The work described in this paper represents experimental and theorectical work of fundamental importance on diffusion in alloys as a function of the structure of the metal and the stress field caused by external action. A brief summary is given of this paper and it is stated that it is not only of major theoretical importance but also of practical interest, particularly from the point of view of the problem of high temperature strength.

Results of the 1958 Competition for Obtaining imeni D. K. Chernov and imeni N. A. Minkevich Prizes, Metallovedeniye i termicheskaya obrabotka metallov, 1959, No. 6, pp 62-64

85379

S/032/60/026/010/007/035
B016/B054

18.7500 2306, 1555, 1146

AUTHORS: Bokshteyn, S. Z., Gubareva, M. A., Kishkin, S. T., and Moroz, L. M.

TITLE: Study of the Process of Iron Recrystallization by the Method of Radioactive Isotopes

PERIODICAL: Zavodskaya laboratoriya, 1960, Vol. 26, No. 10, pp. 1111-1114

TEXT: The authors studied the behavior of atoms at the grain boundaries during the recrystallization of iron (content in %: 0.021 C, 0.014 P, 0.011 S, 0.67 Si, 0.07 Al, 0.08 Mn, 0.06 Ni, 0.033 Cu). Samples of this iron were covered with Fe^{59}. In annealing, Fe^{59} spread due to diffusion at the boundaries between the metal grains. This permitted an observation of the local displacement of atoms lying at the boundary during deformation and recrystallization annealing. Iron rods were annealed at 1250°C for 8 h, and then cut into samples (10 × 10 × 20 mm). The riveted layer (70-80μ) was removed by electropolishing in perchloric and glacial acetic acids. An Fe^{59} layer 1.0 μ thick was electrolytically applied to

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Study of the Process of Iron Recrystallization by the Method of Radioactive Isotopes

S/032/60/026/010/007/03[illegible]
B016/B054

the polished surface. Subsequently, the samples were deformed by compression by 10-16% (Fig. 4) and by 45-70% (Fig. 2). Figs. 1-3 show the autoradiogram (a) on the left, and the microstructure (b) on the right on microphotographs. During exposure the samples were protected by a film 1 μ thick (1% of Zapon varnish in the solvent РДВ (RDV)). To produce the autoradiograms, the samples were exposed for several days on photographic plates or films НИКФИ (NIKFI), type МР(MR). The autoradiograms were compared with the microstructure pictures which had been taken by a microscope of the type МИМ-8 (MIM-8). Next, the recrystallization annealing was carried out (Figs. 3, 5-8). A Table on p. 1113 gives the hardness and the methods of treatment for some samples. On the basis of their methods, the authors succeeded in observing the behavior of grain boundaries during plastic deformation and subsequent recrystallization. It was proved that iron recrystallization at relatively low (15%) and high (50-70%) degrees of deformation causes no essential change in the position of atoms laying at the boundary of deformed grains. With a considerable structural change of the metal after a double recrystallization, as well as

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Study of the Process of Iron Recrystallization by the Method of Radioactive Isotopes

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after polymorphous $\alpha \rightarrow \gamma$ transformation, the atoms at the boundaries of the initial bodies are not displaced. In contrast with recrystallization, plastic deformation is accompanied by a considerable displacement of atoms. The results prove that the displacement of grain boundaries during recrystallization and the subsequent growth of grains is connected with a specific mechanism which differs from the ordinary diffusion mechanism. There are 8 figures, 1 table, and 15 references: 4 Soviet, 1 US, 1 Dutch, 1 French, and 4 German.

Card 3/3

S/129/61/000/001/002/013
E111/E135

AUTHORS: Bokshteyn, S.Z., Doctor of Technical Sciences, Professor; Gubareva, M.A., Engineer; Kontorovich, I.Ye., Doctor of Technical Sciences; and Moroz, L.M., Candidate of Technical Sciences

TITLE: Peculiarities of the Diffusion of Carbon in Iron

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, 1961, No. 1, pp. 10-14 (+ 1 plate)

TEXT: Work by two of the authors (Refs 1-4) and by others (e.g. Refs 2, 3) has shown that diffusion is often non-uniform. This effect could be associated with difference in the activation energy of diffusion (Refs 8-10). In this present work the authors studied diffusion of carbon in technical purity iron (0.03% C) and iron alloys with 0.03% C and 0.14, 0.64 or 2.93% Si. Some alloys also contained a third component: 4.56 or 3[illegible] Ni, 0.36 or 1.61% Al, 0.88, 3.77 or 14.13% Cr, 0.21 or 3% Mo, 1.19 or 4.97% W, 0.1 or 2.29% Ti. This enabled the influence of carbide-forming and non-forming elements to be compared. Prismatic specimens 20 mm high and with a 10 mm base were used. C^{14} was deposited on the surface

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S/129/61/000/001/002/013
E111/E135

Peculiarities of the Diffusion of Carbon in Iron

from barium carbonate or from special specimens containing this isotope. The first technique was used for studies in the gamma, the second in the alpha states. Auto-radiographs were obtained on type НИКФИ (NIKFI) plates, contact prints being examined micro-photometrically with a type МФ-4 (MF-4) instrument. The diffusion coefficient was calculated by the method of Bokshteyn et al (Ref.11). Microstructural analysis was also carried out. Autoradiographs and microstructures for iron at 950 °C are shown in Fig.1a and b. Autoradiographs at 550 °C for alpha iron (unalloyed and with 0.64% Si, top and bottom, respectively) are shown in Fig.2a and b. Fig.5 shows plots of darkening against depth of diffusion of carbon in the grains (top curve) and along boundaries (bottom curve in each of the two diagrams), for ferrite (550 °C). The influence of concentration of the different alloying elements on depth of diffusion (mm) in iron at 950 °C is shown in Fig.6.

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S/129/61/000/001/002/013
E111/E135

Peculiarities of the Diffusion of Carbon in Iron

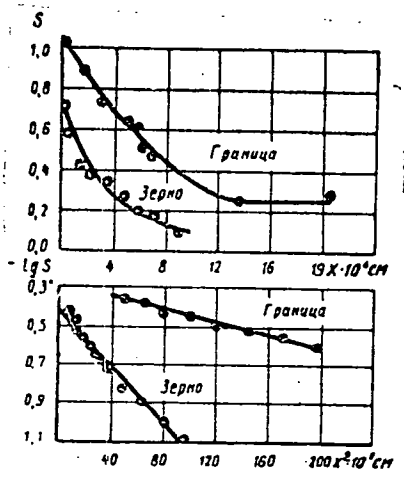

Fig. 5

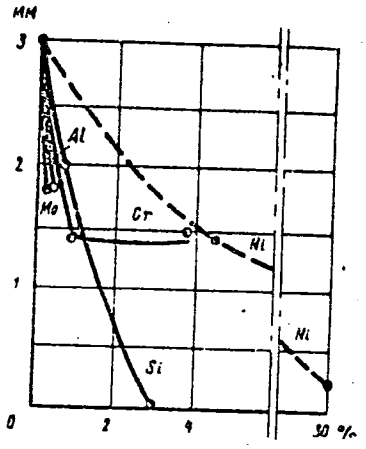

Fig. 6

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Peculiarities of the Diffusion of Carbon in Iron

Fig.7 shows relative darkening with respect to distance into ferrite grain for carbide forming (left-hand graph) and non-forming (right-hand graph) alloying elements. The left and right ends of the plots relate to the grain boundaries; the remaining space, corresponding to 0.30 mm, relates to the body of the grain.

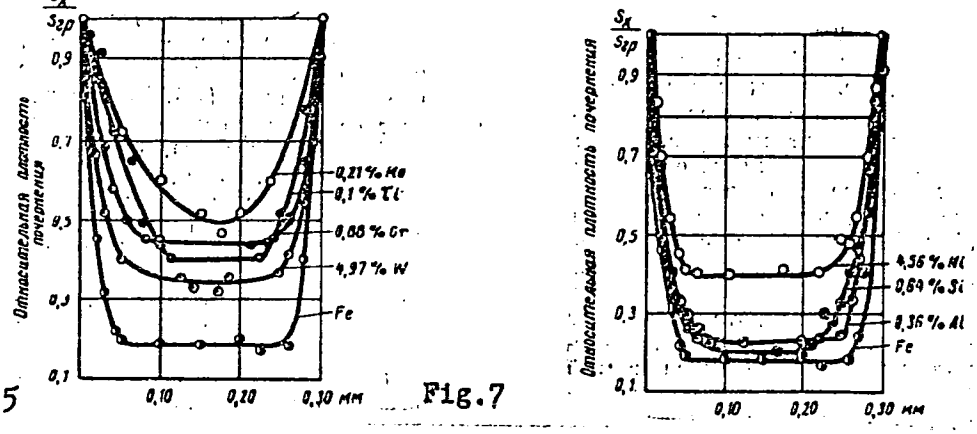

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Fig.7

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Peculiarities of the Diffusion of Carbon in Iron

The work shows that carbon diffusion in both alpha- and gamma-iron occurs unevenly, the grain boundaries and adjacent alpha solid-solution regions becoming enriched with carbon. The diffusion coefficient for grain boundaries is 3-4 orders higher than for inside grains. Alloying modifies both rate of diffusion and distribution of carbon within the grain; depending on the effect of the element on the gamma region. Alloying reduces the carbon-concentration drop between the boundary and the body of the ferrite grain.
There are 7 figures and 11 references: 7 Soviet and 4 non-Soviet.

Card 5/5

BOKSHTEYN, S.Z. (Moskva); KISHKIN, S.T. (Moskva); LOZINSKIY, M.G. (Moskva); SOKOLKOV, Ye.N. (Moskva); Prinimali uchastiye: PODVOYSKAYA, O.N.; ZILOVA, T.K.; SOROKINA, K.P.; POLYAK, E.V.; MOROZ, L.M.; BULYGIN, I.P.; LASHKO, N.F.; POKAMESTOVA, T.N.; GORDEYEVA, T.A.; YAGLOV, R.V.; VOLODINA, T.A.; KORABLEVA, G.N.; ANTIPOVA, Ye.I.

Thermomechanical treatment of chromium-nickel-manganese austenitic steel. Izv. AN SSSR. Otd. tekh. nauk. Met. i topl. no.2:15-21 Mr-Ap '62. (MIRA 15:4)
(Chromium-nickel steel--Hardening)

3481
S/129/62/000/003/002/009
E111/E335

18.7500

AUTHORS Bokshteyn, S.Z., Doctor of Technical Sciences Professor, Kishkin, S.T., Corresponding Member of the Academy of Sciences and Moroz, L.M., Candidate of Technical Sciences

TITLE Influence of carbon on the movement of grain boundaries in the recrystallization of iron

PERIODICAL Metallovedeniye i termicheskaya obrabotka metallov no. 3, 1962, 8 - 13

TEXT Lücke and Detert (Ref. 1 - Acta Metallurg v.5 no 11 1957) and Beck (Ref. 2 - Metal Interfaces Cleveland ASM 1952) consider that there is a sharp drop in the speed of recrystallization when the concentration of an impurity reaches some critical value (about 0.01%) below the solubility. Impurities forming a second phase also retard the growth of recrystallization centres. Using their radioactive-isotopes technique (Ref. 6- "Zavodskaya laboratoriya, no. 10, 1960) the present authors and M.A. Gubareva have studied the influence of carbon on the behaviour of grain boundaries in the recrystallization of

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E111/E335

Influence of carbon on

technical-grade iron. Carbon was chosen as an element practically insoluble in alpha-iron it is known to lead to an increase in the activation energy of recrystallization of iron and, if present in quantities even slighly in excess of its solubility, to prevent collective recrystallization particularly at 620 - 700 °C. Specimens were saturated with carbon from donors at 700 °C for 2 hours The behaviour of carbon atoms at iron-grain boundaries was followed directly during deformation and subsequent recrystallizing annealing. Recrystallization was studied on specimens 10 - 15 and 50 - 70 deformed the first being in fact close to the critical value. Autoradiograms obtained before and after deformation were compared From this and the microstructure the behaviour of the carbon was evaluated. The sizes of all grains increased after deformation. heating to 550 °C failed to produce recrystallization but growth of alpha-phase grains occurred Carbon tended to move towards grain boundaries even when this meant going into a region of higher carbon concentration at 650 °C recrystallization was almost complete the carbon remaining at

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the grain boundaries produced after heating at 550 °C. Although recrystallization was practically instantaneous a completely new fine-grained structure was produced heating to 750 °C produced growth of recrystallized grains and movement not always complete, of carbon to the new grain boundaries. Recrystallization annealing at 700 °C for 45 min of specimens after 13% deformation gave little change in microstructure carbon moved from the boundaries of deformed grains to those of the new recrystallized grains. The influence of the alpha-gamma transformation on the behaviour of carbon atoms located at boundaries was studied in another series of experiments. For this purpose specimens were heated at 950 °C for 1 hour. Completely new grains were produced, the carbon both migrating to them and forming large accumulations of carbides. It is evident that the behaviour of impurity atoms located at boundaries and forming interstitial solutions is very different from that of boundary atoms of the base element, as shown previously (Ref. 6), boundary atoms in iron recrystallization

Influence of carbon on ....

(or polymorphic transformation) remain in practically the same position, carbon atoms follow newly-formed grain boundaries.
There are 6 figures and 1 table.

Card 4/4

S/129/62/000/009/001/006
E071/E492

AUTHORS: Bokshteyn, S.Z., Doctor of Technical Sciences, Professor, Bronfin, M.B., Engineer, Kishkin, S.T., Doctor of Technical Sciences, Professor, Moroz, L.M., Candidate of Technical Sciences

TITLE: Grain boundaries on recrystallization

PERIODICAL: Metallovedeniye i termicheskaya obrabotka metallov, no.9, 1962, 6-8

TEXT: This is a continuation of earlier work ("Zavodskaya laboratoriya", no.10, 1960). The behaviour of W, Ni, Sn and C admixtures present at the grain boundaries during recrystallization of iron (0.021% C, 0.014% P, 0.011% S, 0.67% Si, 0.07% Al, 0.08% Mn, 0.06% Ni, 0.033% Cu) was studied by autoradiographic investigation and microstructural analysis. The admixtures, forming with iron substitutional solid solutions in the case of W, Ni, Sn and interstitial solid solutions in the case of C, were introduced by diffusion saturation at 600 to 700°C. The recrystallization was carried out after preliminary deformations of 10 to 15 and 50 to 70%. The Ni, W and Sn were completely

soluble in iron at all recrystallization temperatures investigated and remained in their original lattice positions, despite substantial changes in the structure of the metal. The behaviour of carbon atoms was substantially different: above 750°C carbon passed from the boundaries of deformed grains to the boundaries of new recrystallized grains. However, in the initial stages of recrystallization (after 30 to 45 min at 650 to 750°C) carbon atoms remain at the boundaries of the [illegible] grains and boundaries of the new grains remain free from carbon. The possibility of "heredity", i.e. preservation of the initial structural and concentration non-uniformities in recrystallized metal was demonstrated on a molybdenum alloy (0.54% Zr, 0.[illegible] 0.0008% Ti and 0.011% C). A thin layer of tungsten 185 was electrodeposited on the surface of a flat specimen of the deformed alloy, submitted to a preliminary annealing at 1700°C. The activated specimen was then annealed in vacuo at 1750°C for 100 hours. Autoradiographs of an oblique section showed the presence of an accelerated diffusion not only along the boundaries of the newly formed grains but also a preferential penetration of

the W^{185} along those sections where old grain boundaries were passing before recrystallization. The velocity of diffusion along the old boundaries was lower than along the new boundaries, nevertheless it was noticeably faster than volume diffusion. The results confirmed that within the grains the process of grain boundary migration does not produce as high concentration of defects as is produced at the beginning and at the end of the boundary migration. There are 6 figures.

BOKSHTEYN, S.Z.; KISHKIN, S.T.; NIKISHOV, A.S.; POLYAK, E.V.; SOLOV'YEVA, G.G.; Prinimali uchastiye: ARZHAKOV, V.M.; BULANOV, A.V.; VERTYUKOVA, L.G.; KORABLEVA; MIRSKIY, L.M.; PODVOYSKAYA, O.N.; SAZONOVA, T.N.; SOLONINA, O.P.; TITARENKO, I.I.; RINK, L.P.; KOZLOVA, M.N.; YERMOLOVA, M.I.; MOROZ, L.M.

Aging of plastically deformed alloys. Metalloved. i term. obr. met. no.5:40-44 My '63. (MIRA 16:5)
(Heat-resistant alloys--Hardening) (Deformations (Mechanics))

ACCESSION NR: AT4013954 S/2659/63/010/000/0214/0218

AUTHOR: Bokshteyn, S. Z.; Kishkin, S. T.; Moroz, L. M.

TITLE: Condition of grain boundaries during recrystallization

SOURCE: AN SSSR. Institut metallurgii. Issledovaniya po zharoprochny*m splavam, v. 10, 1963, 214-218

TOPIC TAGS: metal fatigue, steel grain, recrystallization, grain boundary

ABSTRACT: The present investigation dealt with two problems: First, whether or not the atoms of the initial grain boundary serve as the boundary of the newly-crystallized grains and second, whether or not the initial grains leave traces of their inadequate structure, i.e., whether their inadequacies are completely eliminated during recrystallization. Radioactive isotopes were used for the investigation of the grain boundaries during recrystallization of molybdenum, nickel, iron and iron containing various impurities. The results showed that the atoms of the base metal grain boundary do not take part in creating the grain boundaries of the recrystallized metal and that the boundaries of the recrystallized grains inherit some of the structural features of the initial grain. Orig. art. has: 3 figures.

ASSOCIATION: Institut metallurgii AN SSSR (Institute of Metallurgy AN SSSR)

Card 1/2

ACCESSION NR: AT4040411 S/0000/64/000/000/0074/0094

AUTHOR: Bokshteyn, S. Z.; Kishkin, S. T.; Moroz, L. M.

TITLE: Investigation of the conditions of the grain boundaries during recrystallization of iron and its alloys

SOURCE: Protsessy* diffuzii, struktura i svoystva mettallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 74-94

TOPIC TAGS: iron, iron alloy, steel, tungsten steel, carbon steel, steel structure, grain boundary, recrystallization, iron microstructure, carbon diffusion, tungsten diffusion, tin diffusion, nickel diffusion

ABSTRACT: There are still unclear aspects of the mechanism of recrystallization, such as the nature of the reconstruction of grain boundaries, the formation of new grains and their subsequent growth, the influence of impurities, and the role of diffusion. The present authors investigated recrystallization of iron in specimens previously subjected to a plastic deformation of 10-16 and 45-70%, involving a variety of heat treatments (annealing at 720-800C, recrystallization at 700-1370C, additional heating at 700-950C). Data on microhardness before and after these processes are tabulated. Furthermore, recry-

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ACCESSION NR: AT4040411

stallization was investigated on specimens of iron in which impurities were located at the iron grain boundaries, formed a part of the solid solution by replacement or formed a part of the solid solution by penetration; here again, various degrees of plastic deformation and various heat treatments were applied. The impurities tested were carbon, tin, tungsten and nickel. Finally, radioactive isotopes were used as tracers to observe local displacements of atoms by radio autographs, as well as by photomicrographs and X-ray radiographs. In order to study the behavior of base-metal atoms, the isotope Fe^{59} was used; for the behavior of atoms of an alloying elements, a corresponding isotope of the alloying element was employed. Test specimens 10 x 10 x 20 mm were cut from iron bars previously annealed (1250 C for 9 hrs.) in order to obtain a homogeneous structure and a coarser grain for the convenience of radiographic investigation. After cutting, the work-hardened surface layer (70-80 microns) was removed by electrolytic polishing. The radioactive tracer was deposited on the polished surface electrolytically. Diffusion annealing was carried out in a vacuum furnace at residual pressures of 10^{-3} - 10^{-4} mm Hg. The temperature of diffusion annealing was 720C, at which the influence of grain boundaries on the diffusional flux has been found to be particularly pronounced. Deformation of specimens was carried out in a 200-ton Amsler press. An analysis of the experimental results showed that atoms of soluble impurities (nickel, tungsten, tin), like the atoms of the base-

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showed that atoms of soluble impurities (nickel, tungsten, tin), like the atoms of the base-metal, practically remain at their initial locations despite significant changes in the microstructure of the metal. Prolonged annealing at recrystallization temperature (78 hrs. at 700C for iron with nickel; 30 hrs. for iron with tin; 28 hrs. at 750 C for iron with tungsten), heating at temperatures above the A_3-point, or high-temperature annealing (30 min. at 1200 C for iron with tungsten) did not cause atomic migration of impurities from the initial locations toward the boundaries of the recrystallized grains, regardless of the degree of prior deformation. During recrystallization, atoms of impurities which were located at the grain boundaries and formed part of the solid solution by penetration showed a substantially different behavior than atoms of base-metal at the boundaries or atoms of impurities forming part of the solid solution by replacement. Carbon atoms, unlike atoms of iron, tungsten, nickel, and tin, follow behind the boundaries of newly forming grains, so that at certain stages of the process a lag may occur due to a difference between the diffusion velocity of carbon and the recrystallization velocity. It is characteristic that carbon atoms always migrate toward the grain boundaries, and not in the direction of the maximum concentration gradient of the impurity. The authors suggest, in conclusion, that the activation energy of the migration process be determined and compared with the activation energy of the diffusion process of carbon in iron. Orig. art. has: 25 photomicrographs and 3 tables.

ASSOCIATION: None

ACCESSION NR: AT4040413 S/0000/64/000/000/0099/0109

AUTHOR: Bokshteyn, S. Z; Kishkin, S. T.; Moroz, L. M.; Chaply*gina, V. S.

TITLE: Structure imperfections of metal following recrystallization

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 99-109

TOPIC TAGS: metal structure, metal diffusion, diffusion permeability, metal recrystallization, iron, tin, tungsten, carbon diffusion

ABSTRACT: Many of the properties and processes occurring in metals depend upon the degree of structural perfection. However, it is not clear how and under what circumstances structural defects arise or disappear. In some cases, it has been possible to achieve a displacement of interstitial impurities into the inner regions of grains by recrystallization, thus increasing the plasticity of the alloys. However, such a beneficial influence of recrystallization has been observed only in individual cases. Therefore, the assumption can be made that in regions where grain boundaries have been located before recrystallization, preservation of the specific state is possible, i.e., there is a possibility

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ACCESSION NR: AT4040413

of "heredity". In the present paper, the authors investigated the heredity of metal structure during recrystallization and grain growth, using autoradiographic and microscopic techniques. The degree of structural perfection was evaluated by diffusion permeability of C14, a higher permeability corresponding to a more defective structure. Using specimens of pure iron and of iron containing diffusionally introduced interstitial additions, such as tin and tungsten, the authors studied the stability and degree of defectiveness of the original grain boundaries during recrystallization in relation to the degree of metal purity and the recrystallization conditions. Iron was annealed at 1250C for 9 hrs., electropolished and etched with 4% picric acid in ethanol to reveal the structure. Tin and tungsten were added in a microfurnace at 700C. Recrystallization was then carried out either at 650C for 45 min., at 700C for 30 min. or at 750C for 1 hr., followed by heating at 600C for 1 hr. in the presence of radioactive carbon. Measurements of hardness and C14 distribution demonstrated that diffusion is affected by recrystallization temperature and that the residual effects of previous cold working can remain after application of the common types of recrystallization. The diffusional mobility of atoms was found to increase during the process of recrystallization. Failure of alloys at high temperatures generally proceeds along the grain boundaries, but sometimes it occurs transgranularly. It is possible that, in the latter case, the alloy fails along the boundaries of original

ACCESSION NR: AT4040413

grains which were metallographically undetectable. The question of the influence of various impurities on the defectiveness of the original grain boundaries thus gains considerable significance. It is very possible that inheritance of defectiveness is linked to a considerable degree to the presence of impurities; therefore, the question arises of the possibility of displacing the impurities from the boundaries to the inner region by recrystallization. The results of the present investigation permit the authors to assume that the detrimental influence of impurities can be reduced by applying suitable recrystallization conditions. Orig. art. has: 7 figures and 1 table.

ASSOCIATION: none

SUBMITTED: 09Dec63	DATE ACQ: 28May64	ENCL: 00
SUB CODE: MM	NO REF SOV: 002	OTHER: 000

Card 3/3

ACCESSION NR: AT4040422 S/0000/64/000/000/0183/0187

AUTHOR: Bokshteyn, S. Z.; Kishkin, S. T.; Moroz, L. M.

TITLE: Effect of thermomechanical treatment on diffusion mobility

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 183-187

TOPIC TAGS: thermomechanical treatment, diffusion mobility, diffusion coefficient, fine structure, diffusion mobility determination, thermomechanical treatment effect

ABSTRACT: The diffusion mobility of iron in austenitic steel EI481 and EI437B alloy were investigated after conventional heat treatment and after thermomechanical treatment (TMT). The parameters of the latter treatment were: 1080C - temperature of deformation; 28% - reduction; and 13.5 m/min - deformation rate. The diffusion mobility was determined by the method of tagged atoms in combination with microstructure analysis. The specimens were electrolytically coated

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ACCESSION NR: AT4040422

with a thin film of radioactive Fe^{59} and annealed in a vacuum furnace at 800C for 150 hr. After annealing, the diffusion coefficients were calculated for grain volume and grain boundaries. Table 1 (see enclosure) presents the results obtained. Thus, TMT changes not only the conditions of the grain boundaries but of the grain bodies as well. The increase of diffusion mobility is preserved even after annealing at higher temperatures (temperature of recrystallization). The increase of diffusion mobility produced by TMT limits the applicability of this method for heat-resistant alloys. TMT could be beneficial, however, for alloy working at relatively low temperature. Orig. art. has: 4 figures and 2 tables.

ASSOCIATION: none

SUBMITTED: 09Dec63	ATD PRESS: 3072	ENCL: 01
SUB CODE: MM	NO REF SOV: 001	OTHER: 00

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ACCESSION NR: AT4040422 ENCLOSURE: 01

Table 1. Iron diffusion coefficients D·10 cm /sec on grain boundaries Dgr and in grain bodies Db of alloys EI437B and EI481 at 800C

Alloy	Conventional heat treatment		TMT	
	Dgr	Db	Dgr	Db
EI481	0.62	4.6	2.8	—
EI437B	0.87	3.5	1.7	11
Average diffusion coefficient				
EI481	1.4		3.0	
EI437B	1.0		1.3	

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L 07382-67 EWT(m)/EWP(t)/ETI LJP(c) JD/JG
ACC NR: AP6027751 (N) SOURCE CODE: UR/0370/66/000/004/0139/0142

AUTHOR: Bokshteyn, S. Z. (Moscow); Kishkin, S. T. (Moscow); Moroz, L. M. (Moscow); Chaplygina, V. S. (Moscow)

ORG: None

34
B

TITLE: Characteristics of carbon diffusion in niobium

SOURCE: AN SSSR. Izvestiya. Metally, no. 4, 1966, 139-142

TOPIC TAGS: carbon, niobium, metal diffusion

ABSTRACT: The nature of carbon diffusion in niobium is studied as a function of structure and surface state. The specimens were melted in a vacuum arc furnace, forged and heat treated at 2000°C for 10 hours to produce a uniform structure and relieve internal stresses. Carbon diffusion was studied by autoradiography combined with microstructural analysis. The niobium specimens were diffusion saturated with radioactive carbon at 900°C for 2 hours. Three types of carbon diffusion measurement in the surface layer were compared: 1. directly after stabilizing annealing in a vacuum at 2000°C for 10 hours; 2. after stabilizing annealing and mechanical destruction of the surface layer by polishing the specimens on glass with abrasive powders of varying granularity and by preparation of a microsection; 3. in the oxidized surface of a microsection. It was found that considerable diffusion of carbon takes place along the

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ACC NR: AP6027751

grain boundaries of the niobium regardless of the state of the surface layer. The surface state has a considerable effect on volumetric diffusion. Annealed specimens show practically no volumetric diffusion while specimens with a polished surface show considerable mobility of carbon atoms within the niobium grains. This diffusion is considerably stronger along the subgrain boundaries than in the remainder of the grain volume. Analysis of the experimental results shows that carbon diffusion in niobium consists of three elementary processes: 1. diffusion of carbon in the crystal lattice of niobium; 2. reactive diffusion with the formation of a carbide phase; 3. diffusion of carbon in niobium carbides. The carbide phase is formed chiefly in defect sections of the structure: along the boundaries of grains and subgrains and also in the less perfect sections of the grain volume where diffusion is most intense. Orig. art. has: 1 table.

SUB CODE: 11,07/ SUBM DATE: 09Mar65/ ORIG REF: 006/ OTH REF: 005

Card 2/2 KS

ACCESSION NR: AT4040404 S/0000/64/000/000/0015/0024

AUTHOR: Gubareva, M.A.; Moroz, L.M.

TITLE: A study of self diffusion and diffusion in nickel alloys

SOURCE: Protsessy* diffuzii, struktura i svoystva metallov (Diffusion processes, structure and properties of metals); sbornik statey. Moscow, Izd-vo Mashinostroyeniye, 1964, 15-24

TOPIC TAGS: nickel, nickel alloy, Kh20N80T3 alloy, ZhS3 alloy, nickel self diffusion, boundary diffusion, bulk diffusion, autoradiographic diffusion analysis, self diffusion coefficient, diffusion activation energy, tin, tin diffusion

ABSTRACT: The authors present a detailed analysis of autoradiographic diagrams of diffusion in nickel and offer some qualitative evaluations of the diffusion of tin and self-diffusion of nickel in nickel and nickel-based alloys. They demonstrate the heterogeneity of the self-diffusion process and the significance of grain boundaries, temperature and composition or structural factors for the processes of self-and hetero-diffusion. Prismatic samples of technically pure Ni, Ni plus 0.01% B, Ni plus 0.6% W and of alloy Kh20N80T3 were annealed at high temperatures (1 hr. at 1100C, 12 hrs. at 1100C, 9 hrs. at 1200C and 2 hrs. at 1200C,

ACCESSION NR: AT4040404

respectively; all cooled in the furnace to 900C, then in free air), then polished electrolytically and electroplated with Ni^{63} (coat thickness up to 1 μ). Plated samples were homogenized in a vacuum furnance at 700, 800, 1000 or 1200C. Effects of structural factors on diffusion rate were studied on cast or forged samples of alloy ZhS3 which were air-cooled after 7 hrs. at 1150C, then homogenized in argon at 800, 850 or 950C. It was found that self-diffusion of Ni proceeded mainly along the grain boundaries within the range of 800-1200C. Self-diffusion coefficients ranged from 2.0 to $56.0 \cdot 10^{12}$ cm^2/sec for pure Ni at 800 and 1200C, respectively and 0.6 to 28.0 for alloy Kh20N80T3 at such temperatures. The activation energy was 24,800 kcal/g-atom. Coefficients of tin diffusion in ZhS3 ranged from 0.3 to $23.0 \cdot 10^{13}$ cm^2/sec (for cast material) at 800 and 950C, respectively and from 0.8 to 33.0 for forged material. The ratio Q_{surf}/Q_{bulk} was 0.75, 0.62 and 0.52, respectively, for ZhS3, KH20N80T3 and pure nickel. Orig. art. has: 5 tables and 7 figures.

ASSOCIATION: none

SUBMITTED: 09Dec63 DATE ACQ: 28May64 ENCL: 00

SUB CODE: MM NO REF SOV: 001 OTHER: 008

Card 2/2

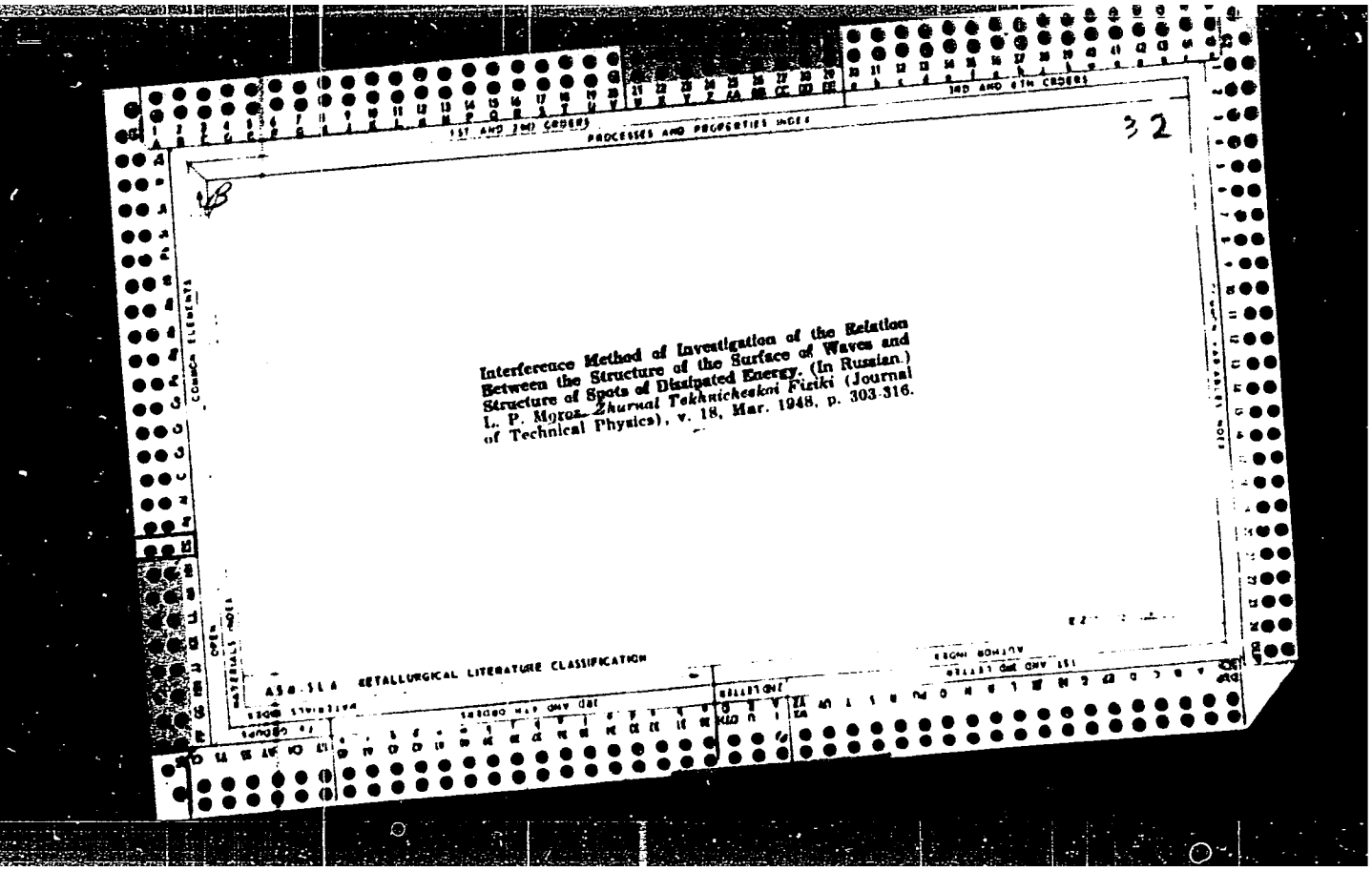
MOROZ, L. F.

"Resolution Limit of [illegible] Optical Instruments," [illegible], 41, No. 9, 1943.

State Optical Inst.

MORGI, L. P.

"Limit of the Resolving Power of the Photographic Optical Apparatus," Zhur. Tekh. Fiz., 14, Nos. 4-5, 1944.



Interference Method of Investigation of the Relation Between the Structure of the Surface of Waves and Structure of Spots of Dissipated Energy. (In Russian.) L. P. Mgrua. *Zhurnal Tekhnicheskoi Fiziki* (Journal of Technical Physics), v. 18, Mar. 1948, p. 303-316.

Weisz, L.P.

Photochemistry

Combined reversible power of the [illegible] layer and [illegible].
Ber. Bauch. Fot., No. 3, 1 1.

Monthly List of Russian Accessions, [illegible].

AUTHOR: Moroz, I.F.

TITLE: The Theory of the Threshold Characteristics of the Photographic Apparatus (Teoriya porogovykh kharakteristik fotografiruyushchego pribora)
I. The Role of the Optical System of the Apparatus in the Case of Individual Objects in the **Vision Area** (Rol' opticheskoy sistemy pribora v sluchaye otdel'nykh ob"yektov v pole zreniya)

PERIODICAL: Zhurnal nauchnoy i prikladnoy fotografii i kinematografii, 1958, Vol 3, Nr 6, pp 443-449 (USSR)

ABSTRACT: The author interpreted the theory of the threshold characteristics of photographic apparatus at the open sessions of the Commission for Scientific Photography and Cinematography of the AS USSR in Leningrad and Moscow in October and December 1957. In this first part he is concerned with the contrast in the real image in the case of individual grey objects located in fields brighter or darker than the objects themselves. Equations for a determination of the relevant threshold characteristics are discussed. It is concluded that, upon a comparison of the resulting final equations, it is possible

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The Theory of the Threshold Characteristics of the Photographic Apparatus. I. The Role of the Optical System of the Apparatus in the Case of Individual Objects in the **Vision Area**

to cover threshold characteristics also in the cases of entirely different objects, optical systems and photographic apparatus that have scattering properties.
There are 3 graphs, 1 diagram and 2 references, one of which is Soviet and 1 British.

SUBMITTED: December 12, 1957

Card 2/2

AUTHOR: Moroz, L.P. SOV/51-5-6-9/19

TITLE: Formation of Images of Objects, in a Field which is Brighter or Darker than the Objects Themselves, by an Aberrationless Optical System (Izobrazheniye bezaberratsionnoy opticheskoy sistemoy otdel'nykh ob"yektov, nakhodyashchikhsya v pole, boleye ili menoye svetlom, chem sami ob"yekty)

PERIODICAL: Optika i Spektroskopiya, 1958, Vol 5, Nr 6, pp 692-698 (USSR)

ABSTRACT: The object is a band in a field which is either brighter or darker than the object itself. This object is imaged by an aberrationless optical system with a circular aperture. The author obtains an equation which relates together the object width, its contrast with the surrounding field, the contrast between a point on the object axis and the surrounding field, the aperture of the optical system and the wavelength used. This equation makes it possible to find the limiting values of each of the listed quantities, when the other quantities are given, as a function of the limit of sensitivity to contrast of the receiver used. The following special cases are considered: contrast in a real image of a black band in a bright field as a function of the object (band) width, contrast in a real image of a grey band in a field brighter than the band, contrast in a real image of a grey band in a

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Formation of Images of Objects, in a Field which is Brighter or Darker than the Objects Themselves, by an Aberrationless Optical System

field darker than the band. The form of the equation derived by the author depends on whether the object is darker or brighter than the field for a given contrast of the object with the field. The method which was used to obtain this equation may be applied to objects of other shapes, to optical systems with other properties and to receivers which have scattering properties. The paper is entirely theoretical. There are 4 figures, 1 table and 2 references, 1 of which is Soviet and 1 English.

SUBMITTED: November 5, 1957

Card 2/2

23(1) SOV/77-4-2-1/18

AUTHOR: Moroz, L.P.

TITLE: The Theory of the Threshold Characteristics of a Photographic Instrument (Teoriya porogovykh kharakteristik fotografiruyushchego pribora) 2. Problems Arising During the Design and Operation of Photographic Instruments (Zadachi, voznikayushchiye pri konstruirovanii i ekspluatatsii fotografiruyushchikh priborov)

PERIODICAL: Zhurnal nauchnoy i prikladnoy fotografii i kinematografii, 1959, Vol 4, Nr 2, pp 81-89 (USSR)

ABSTRACT: At the open scientific sessions of the Komissiya po nauchnoy fotografii i kinematografii AN SSSR (Committee for Scientific Photography and Cinematography of the AS USSR) in Leningrad and Moscow in the winter of 1957, the author stated that the threshold characteristics of a photographic instrument depend on the qualities of its optical system and its image receiver. If the optical

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The Theory of the Threshold Characteristics of a Photographic Instrument, 2. Problems Arising During the Design and Operation of Photographic Instruments.

system is non-aberrational with a circular aperture and the object is a strip of any given width, placed in a field lighter or darker than itself, then due to diffraction, the optical system will convert each emitting line into a band of energy dispersion. Using the grapho-analytical method of consideration [1], the author produced an equation connecting the following: 1) the width of the separate object in the form of a strip; 2) the linear δ or the angular α (in cases when the strip is placed in a lighter and darker field than itself); 3) its contrast K with the surrounding field; 4) the contrast K_i between a point on its axis and the surrounding field in the image, formed by a non-aberrational system with a circular aperture; 5) the aperture of this system (the numerical aperture A or the diameter

The Theory of the Threshold Characteristics of a ...graphic Instrument, 2. Problems Arising During the Design and ...tion of Photographic Instruments.

D of the entry pupil); and 6) the length of the wave of the emission λ. If the object is darker than the field the equation looks as follows:

$$0.88A\delta + \lg\left(1-\frac{K_i}{K}\right) = 0 \text{ or } 0.44D\chi + \lambda \lg\left(1-\frac{K_i}{K}\right) = 0 \quad (1)$$

and if the object is lighter than the field;

$$0.88A\delta + \lambda \lg\frac{1-\frac{K_i}{K}}{1-K_i} = 0 \text{ or } 0.44D\chi + \lambda \lg\frac{1-\frac{K_2}{K}}{1-K_i} = 0 \quad (1')$$

These equations make it possible to find the necessary, particularly the threshold values of each of the enumerated values when the remaining values are given. By contrast the relationship $\frac{\text{light-dark}}{\text{light}}$ is understood in all

The Theory of the Threshold Characteristics of a Photographic Instrument, 2. Problems Arising During the Design and Operation of Photographic Instruments.

cases. The author defines some of the other values more closely and demonstrates the accuracy of results obtained by equations (1) and (1') and other given equations, and the graphic method of solution which permits greater accuracy. He shows how to calculate by integration (see table) the value of Kiot (image contrast in the case of a black object in the field, i.e. when K=1) and to present in the form of a graph, the relationship between Kiot and the values d where A=n sin u - the numerical aperture of the system (n is the refractive index of the medium in front of the system; u is the aperture angle from the side of the area of the objects). He derives equations (2) and (2'), (3) and (3') which are simplifications of equations (1) and (1'). The author then turns to formulating and solving

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The Theory of the Threshold Characteristics of a Photographic Instrument, 3. Problems Arising During the Design and Operation of Photographic Instruments.

typical problems, arising during the design and use of photographic instruments and instruments consisting of an optical system and an image receiver. These are as follows: 1) Finding the size of an object of a given contrast with the field, formed by an optical system with a previously given contrast on the receiver; 2) Finding the least contrast value between the object and the field at which the instrument will discover its existence there; 3) Finding the necessary value of the threshold of perceiving the contrast of the instrument's receiver so that the latter may discover the existence of an object of a given size and contrast with the field; 4) Finding the necessary value of the aperture of an optical system from the side of the image area (in particular, the value of the focal distance

The Theory of the Threshold Characteristics of a Photographic Instrument, 2. Problems Arising During the Design and Operation of Photographic Instruments. 307/77-4-2-1/13

of the instrument's optical system) at which a given object of a given contrast with the field will be at the limit of instrument discrimination; 5) Finding the necessary value of the numerical aperture of an optical system (or the diameter of its entry pupil) where an object of given contrast with the field will be represented on the receiver with a previously given contrast; 6) Finding the necessary value of the numerical aperture of an optical system (or the diameter of its entry pupil), where the instrument will still discover a given object of a given contrast with the field; 7) Finding the greatest distance to a given object of a given contrast with the field, where the instrument will still discover its existence; 8) various other problems. The author finally draws the following conclusions 1) Equa-

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The Theory of the Threshold Characteristics of a Photographic Instrument, 2. Problems Arising During the Design and Operation of Photographic Instruments.

tions have been derived which connect the width of a separate object in the form of a strip (when it is placed in a field lighter or darker than itself), its contrast with the surrounding field, the contrast between a point on its axis and the surrounding field in the image, formed by a non-aberrational optical system with a circular aperture, the aperture of this system and the length of the waves of emission 2) The form of the equation differs according to whether the object is lighter or darker than the field, at a given contrast between the object and the field. A connection between both cases has been established. 3) The equation makes it possible to find the requisite or threshold values of any of the enumerated values, when the remaining values are given, in connection with the values of the threshold of contrast

The Theory of the Threshold Characteristics of a Photographic Instrument, 2. Problems Arising During the Design and Operation of Photographic Instruments.

perception of the instrument receiver 4) Some typical problems of threshold characteristics, arising during the design and use of photographic instruments, have been formulated and solved. An analysis has been given of these solutions. There are 1 table and 3 Soviet references.

PRESENTED: October 9, 1957 and December 11, 1957,

SUBMITTED December 12, 1957

MOROZ, L.P.

Theory of the threshold characteristics of the photographic mechanism. Part 4: Reproduction of details in the form of separate slits of any width and any contrast with the field by the complex function of the optical system and photographic layer. Zhur.nauch.i prikl. fot. i kin. 6 no.2:130-138 Mr-Ap '61. (MIRA 14:4)
(Photographic optics) (Photographic emulsions)

MOROZ, L.P.

Imaging of separate linear objects of different width and contrast with the field surrounding them by combining an optical system and a gramular layer. Opt. i spektr. 10 no.2:249-256 F '61.
(MIRA 14:2)

(Optics)

43408
S/051/62/013/005/014/017
E032/E314

AUTHORS: Kirilyuk, Z.O. and Moroz, L.P.

TITLE: The effect of stray light on the diffraction pattern of isolated line objects

PERIODICAL: Optika i spektroskopiya, v. 13, no. 5, 1962, 734 - 739

TEXT: Stray light due to sources inside or outside an optical instrument is superimposed on the image produced by the latter and may have an appreciable effect on the threshold characteristics of the instrument. The formulae derived in this paper may be used to take into account the effect of the background, whatever its origin, on the contrast of the diffraction images of line objects (wires or slits) and their immediate neighbourhood for different object widths, wavelengths, aperture of the systems, contrast between the object and its immediate neighbourhood and contrast between this neighbourhood and the general illumination field. Using the approximate energy-distribution in the diffraction pattern of a luminous line, derived in earlier papers (L.P. Moroz, Zh.nauchn. i prikl. fotogr. i kinematogr., 5, 81,1959;

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The effect of ....

Opt, i spektr., 10, 249, 1961), explicit expressions are obtained for the threshold widths of dark objects for different contrasts. These expressions have been verified experimentally by the microphotometry of diffraction patterns due to wires 0.02 - 0.1 mm in diameter with differently illuminated backgrounds. The results obtained are summarized in a numerical table which indicates good agreement between experimental results and the theoretical formulae. These formulae may therefore be used in practice to determine any of the quantities listed above when all the others are given. There are 2 figures and 1 table.

SUBMITTED: October 4, 1961

Card 2/2

MOROZ, L.P.; AYUKHANOV, A.Kh.

Possibility of determining the effective depth of the yield of secondary electrons in the ion-electron emission from dielectrics. Izv. AN SSSR. Ser.fiz. 26 no.11:1322-1327 N '62. (MIRA 15:12)

(Secondary electron emission) (Dielectrics)

S/109/63/008/002/018/028
D413/D408

AUTHORS: Moroz, L.P. and Ayukhanov, A.Kh.

TITLE: On the ratio between the negative-ion and electron components of the secondary emission from NaCl films bombarded by Na^+, Rb^+ and Cs^+ ions

PERIODICAL: Radiotekhnika i elektronika, v. 8, no. 2, 1963, 322-327

TEXT: Several workers have studied the negative secondary emission from alkali halide films bombarded by ions, but have not distinguished between the negative-ion and electron components, which can give misleading results. The authors have measured these components in the emission from NaCl films on Mo or Ta under bombardment by Na^+ and Cs^+ ions in the energy range 150 - 2100 ev and Rb^+ ions in the range 200 - 1600 ev, during deposition of the NaCl. The characteristic of the negative-ion emission agreed closely with that of the positive-ion emission, rising sharply to saturation at a thickness corresponding to a mon-atomic layer and being substantially in-

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dependent of the mass and energy of the primary ions. The secondary electron emission behaved quite differently, rising only slowly with film thickness to saturate at a layer tens of atoms thick, and increasing markedly with increase in energy and decrease in mass of the primary ions. Thus the ratio between the two components of the negative secondary emission may vary widely with the film thickness and the mass and energy of the bombarding ions, and few conclusions can be drawn from the total value of negative emission current. There are 6 figures.

SUBMITTED: March 19, 1962

Card 2/2

L 41698-65 EWT(1)/EPA(sp)-2/EPF(c)/EPA(w)-2/EEC(t)/EWA(m)-2 Pi-4/Pr-4/Pz-6/
Pab-10/Peb IJP(c) AT/WW
ACCESSION NR: AR5008426 UR/0058/65/000/001/H060/H060

SOURCE: Ref. zh. Fizika, Abs. 1Zh379

AUTHORS: Moroz, L. P.; Ayukhanov, A. Kh.

TITLE: On the possibility of determining the depth of penetration of ions in a solid by means of secondary ion-electron emission

CITED SOURCE: Dokl. AN UzSSR, no. 6, 1964, 15-18

TOPIC TAGS: electron emission, ion bombardment, secondary emission, thin film, penetration depth

TRANSLATION: Two possible mechanisms are considered for the knocking out of secondary electrons from the target substance: the direct action of the bombarding ions themselves, and the production of electrons by the recoil atoms (i.e., by the target atoms situated in this region) in cascaded transport of large batches of energy. To explain the role of each of these mechanisms, experiments were carried out that yielded the dependences of the coefficient of

Card 1/2

L 11698-65

ACCESSION NR: AR5008426

ion-electron emission on the thickness of NaCl and RbCl films evaporated in vacuum on a molybdenum substrate, the films being bombarded with K^+, Cs^+, and Na^+ and Rb^+ ions, respectively. It is established that secondary electrons are emitted from a layer of equal thickness in the case when the bombarding ions have equal velocities. Starting from this experimental fact, it is asserted that the electron emission from deep layers of the target is due to the primary ion beam itself. On the basis of such a conclusion, the authors believe that the secondary ion-electron emission can be used to study the depth of penetration of the ions in a solid. V. Shustrov.

SUB CODE: NP ENCL: 00

Card 2/2

MOROZ, L.P.; AYUKHANOV, A.Kh.

Use of the secondary ion-electron emission method in the comparative study of the depth of penetration of various ions into dielectric films. Izv. AN SSSR. Ser. fiz. 28 no.8:1395-1400 Ag '64 (MIRA 17:8)

L 6802-65 EWT(l)/EWT(m)/EPA(w)-2/EEC(t)/T/EEC(b)-2/EWP(q)/EWP(b) Pab-24 91
IJP(c)/ASD(d)/ASD(a)-5/ASD(m)-3/AFWL/ESD(dp)/ESD(gs)/ESD(t)/RAEM(t)
ACCESSION NR: AP4044661 S/0048/64/028/008/1395/1399

AUTHOR: Moroz, L.P.; Ayukhanov, A.Kh.

TITLE: Comparative study of the depth of penetration of different ions into dielectric films by a secondary ion-electron emission method /Report, Third All-Union Conference on Semiconductor Compounds held in Kishinev 16-21 Sep 1963/

SOURCE: AN SSSR. Izv. Seriya fizicheskaya, v.28, no.8, 1964, 1395-1399

TOPIC TAGS: ion deceleration, ion interaction, thin film, secondary electron, sodium chloride, rubidium compound, chlorine compound, sodium ion, cesium ion, potassium, rubidium, ion

ABSTRACT: A method for determining the relative depth of penetration of different ions into the same dielectric film was devised and applied to the investigation of the penetration of Na^+ and Rb^+ ions into RbCl films and K^+ and Cs^+ ions into NaCl films. In this method the penetration of the ions into the film is followed by observing the secondary electrons that are emitted, and the maximum depth from which secondary electrons originate is regarded as the penetration depth. To determine this depth, the thickness of the film is continuously increased during the measure-

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ments; the yield of secondary electrons accordingly rises until the thickness of the film reaches the critical value, after which the yield remains constant. In the experiments reported, the salt films were produced by evaporation onto a 1.5 x 40 mm^2 molybdenum substrate. Ions from two separate sources were directed onto this substrate at equal small angles of incidence, and the secondary electron current was monitored with an oscilloscope. The two ion beams were modulated by square waves of different frequencies, so that one could observe on the oscilloscope the electron currents produced by each of the two ion beams separately, and by both of them together. The less penetrating beam was the one for which saturation of the secondary current set in first. The actual thickness of the film was not measured, so that only which of the two beams was the more penetrating could be determined. The advantage of the method is that the two kinds of ion are observed in the same film, thus obviating the problem of reproducibly forming and manipulating uniform thin films. The experiments with Na^+ and Rb^+ ions on RbCl films and K^+ and Cs^+ ions on NaCl films were conducted at ion energies from several hundred to several thousand electron-volts. It was found that the two ions penetrated to the same depth when their initial velocities were equal. From this and the fact that the ions differed greatly in mass it is concluded that the secondary electrons originating at the greatest depths were ejected directly by the ions themselves rather than by

L 6802-65
ACCESSION NR: AP4044661

atoms of the film to which the ions might have transferred their momentum as in a relay race. It is inferred that the conclusion of L.P.Moroz and A.Kh.Ayukhanov (Izv.AN SSSR.Ser.fiz.26,1322,1962) that secondary electrons produced by ions and those produced by electrons originate at the same effective depth is erroneous, and that when the two phenomena are observed in the same growing film it is found that the effective depth for electron-electron emission exceeds that for ion-electron emission by a factor 1.3. Orig.art.has: 5 figures.

ASSOCIATION: none

SUBMITTED: 00 ENCL: 00

SUB CODE: NP,GP NR REF SOV: 005 OTHER: 000

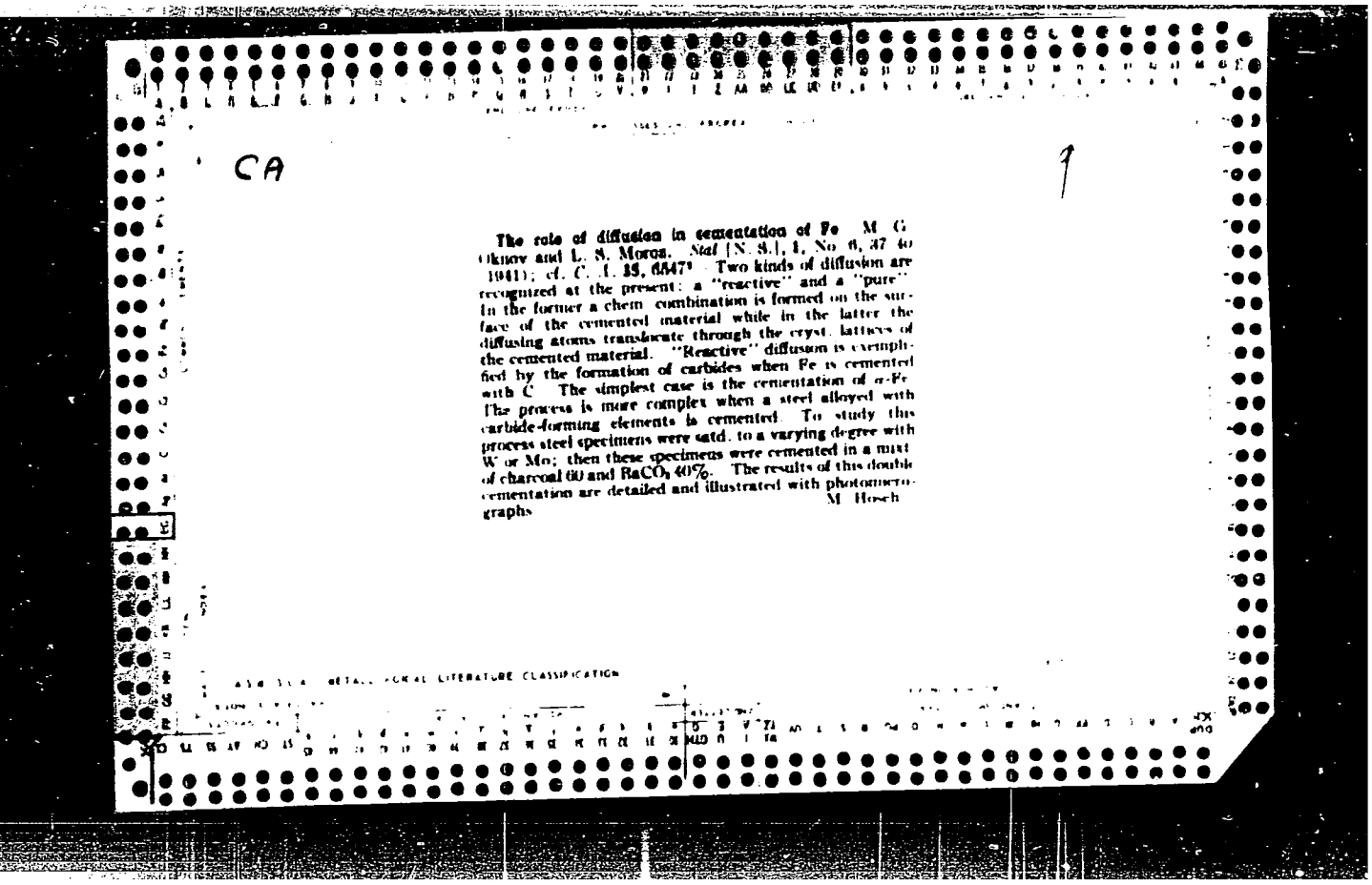
3/3

MOROZ, L.S.

Sensory innervation of the cranial mesenteric artery [with summary in English]. Biul.eksp.biol. i med. 43 no.3:107-110 Mr '57.
(MLRA 10:7)

1. Iz kafedry normal'noy anatomii (zav. - prof. G.F.Ivanov [deceased]) I Moskovskogo meditsinskogo instituta. Predstavlena akademikom A.D. Speranskim.

(ARTERIES, MESENTERIC, innerv.
sensory innerv. of cranial mesenteric artery (Rus))



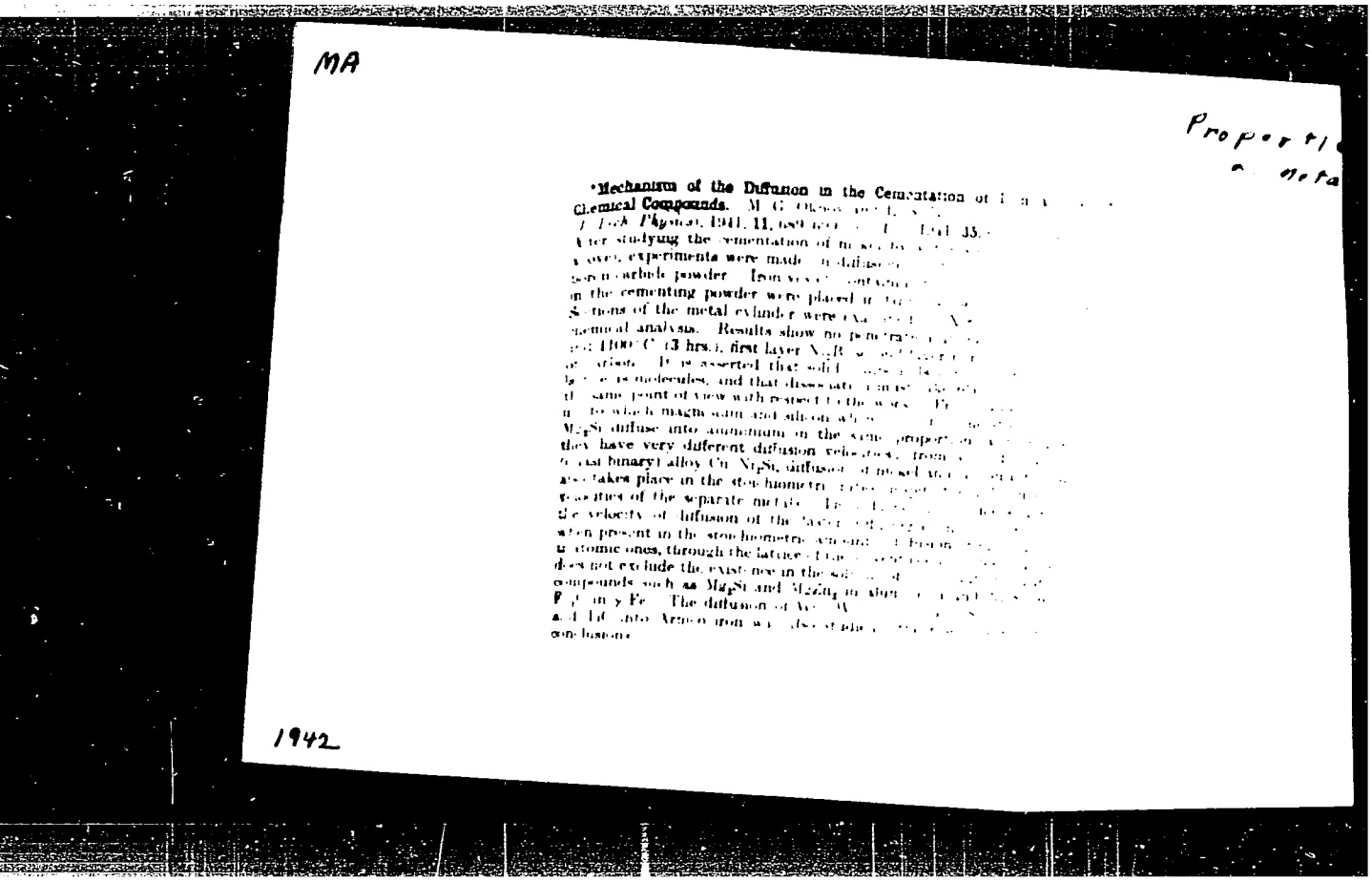
CA

9

The rate of diffusion in cementation of Fe M. G. Okunov and L. S. Moros. *Stal* [N. S.], 1, No. 6, 37-40 (1941); cf. C. A. 35, 6647⁹. Two kinds of diffusion are recognized at the present: a "reactive" and a "pure". In the former a chem. combination is formed on the surface of the cemented material while in the latter the diffusing atoms translocate through the cryst. lattices of the cemented material. "Reactive" diffusion is exemplified by the formation of carbides when Fe is cemented with C. The simplest case is the cementation of α-Fe. The process is more complex when a steel alloyed with carbide-forming elements is cemented. To study this process steel specimens were cemtd. to a varying degree with W or Mo; then these specimens were cemented in a mixt. of charcoal 60 and $BaCO_3$ 40%. The results of this double cementation are detailed and illustrated with photomicrographs. M. Hosch

Mechanism of diffusion of various elements in iron and nickel M. G. Oknov and L. S. Moroz. *J. Tech. Phys.* (U. S. S. R.) 11, 593-600(1941). Cylindrical (diam. 9 mm., height 20 mm.) samples of Armco iron and electrolytic nickel are cemented in Mo, W, Si and Be powders, with oxidation excluded, at temp. from 800 to 1200°, for up to 50 hrs. After cooling, 0.05 to 0.1 mm. thick slices are turned off and subjected to chem., micrographic and x-ray analysis (Debye, Co K_α and K_β lines). (1) Diffusion of Mo and W in Fe: after short cementations (Mo, 3 hrs. at 950° or 2 hrs. at 1000° or 45 min. at 1200°; W, 2 hrs. at 1100° or 1 hr. at 1200°) the diffusion layer consists of solid solns. of Mo (W) in γ-Fe; after longer diffusions (Mo, 25 hrs. at 1000°; W, 20 hrs. at 1200° or 12 hrs. at 1250°), the first layer is an intermetallic compd. (Fe_3Mo_2, Fe_2W), the second layer a solid soln. of Mo (W) in α-Fe. Plots of Mo (or W) content against thickness of diffusion layer show, in the case of sufficiently long cementations, const. Mo (or W) contents, corresponding to that of the intermetallic compd., in layers 0.1-0.2 mm. thick, irrespective of the conditions of the cementation (temp., duration); at a definite thickness, there is a sudden drop of the Mo (W) content, which now becomes dependent of the duration and temp. and decreases with increasing thickness. (2) Diffusion of Si in Fe: 30 min. at 1120°, solid soln. of Si in α-Fe; 10 hrs. at 1120°, first-layer compd. Fe_3Si (14% Si), second-layer 8.8% Si. (3) Be in Fe: 10 hrs. at 1000° (or 3 hrs. at 1080°), first-layer $FeBe_2$, second-layer compd. with solid soln. of Be in α-Fe (8.9% Be). Plot of % Be against thickness, for the cementation [illegible] hrs., shows const. 20% Be up to 0.18 mm., dropping suddenly to 8.5% and then decreasing to 2.5% at 0.4 mm. (4) Si in Ni: 30 min. at 800°, solid soln. of Si in Ni; 1 hr. at 800°, first-layer compd. Ni_3Si, second solid soln., 2.8% Si; 10 hrs. at 800°, first layer Ni_3Si, second solid soln., 6.4% Si. (5) B in Ni: 1 hr. at 950°, compd. Ni_2B; no change of phase and compn. occurs in longer cementation, up to 10 hrs. at 950°; the same compd. grows in thickness as diffusion proceeds, without undergoing soln. (6) Be in Ni: diffusion gives rise from the outset to formation of compd. Ni_5Be_{21}, second layer (10 hrs. at 950° or 7 hrs. at 1050°), solid soln. of Be in Ni. From the foregoing results, substantiated by metallography, analysis and x-ray evidence, it is inferred that the first stage of solid diffusion consists in solid soln., followed soon by compd. formation; this takes place as soon as the rate of chem. interaction outgrows the rate of soln. of the intermetallic compd. in the pure metal; the former rate is practically only dependent on the temp., and invariable with time, while the latter strongly decreases with progressing diffusion. The solid diffusion process here investigated is termed "reactive" diffusion, as opposed to the "pure" or phys. diffusion exempt of chem. interaction. It is also concluded that α-Fe has a higher reactivity toward Mo, W, Si, Be and B than γ-Fe. N. Thon

ASB-SLA METALLURGICAL LITERATURE CLASSIFICATION



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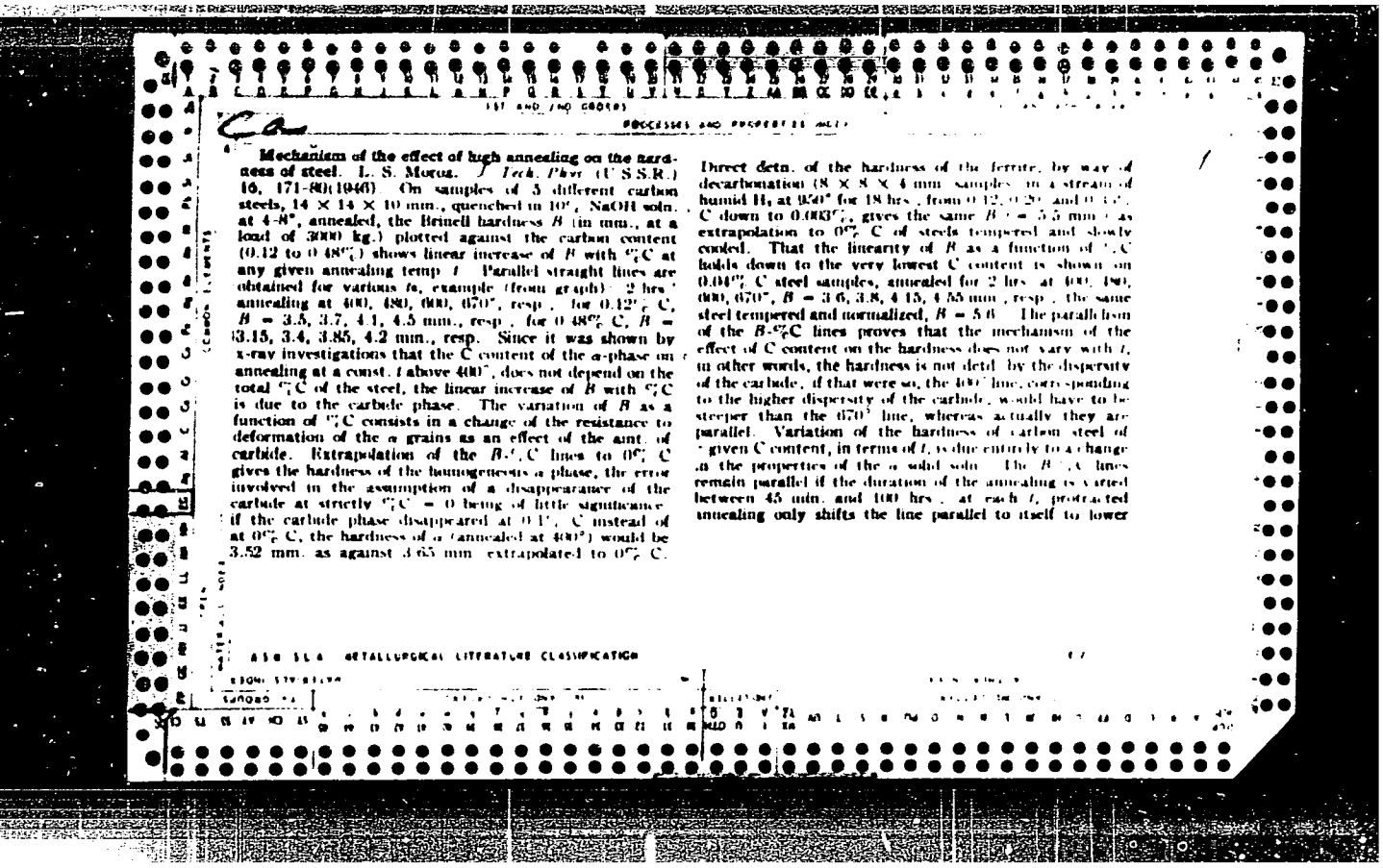
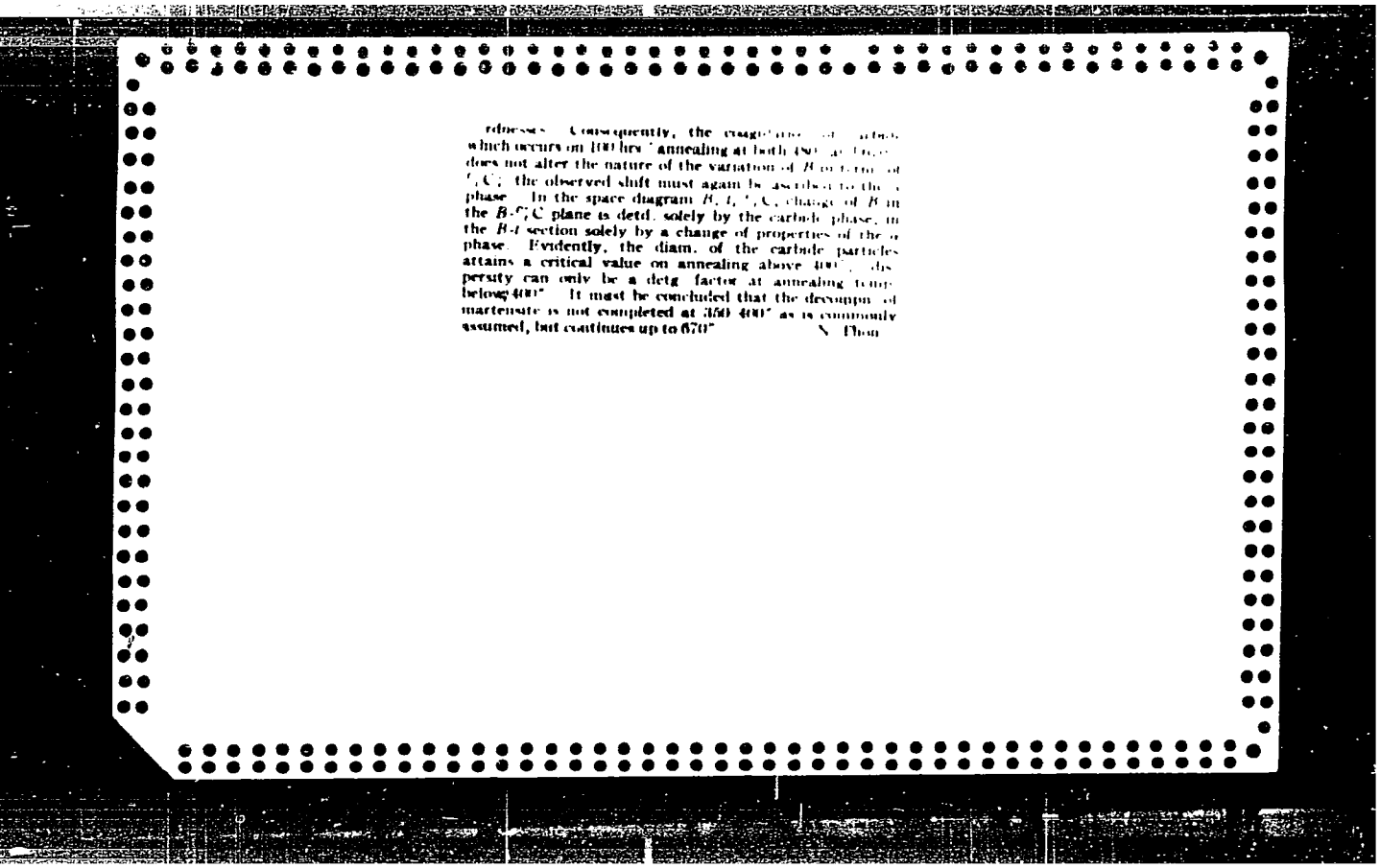
•Mechanism of the Diffusion in the Cementation of
Chemical Compounds. M
J. Tech. Phys. 1941, 11,
After studying the cementation of
seven experiments were made
powdered carbide powder. Iron
in the cementing powder were placed
Sections of the metal cylinder were
chemical analysis. Results show no
at 1000° C. (3 hrs.), first layer
of alloy. It is asserted that solid
by ions or molecules, and that dissociation
the same point of view with respect to the
in which magnesium and silicon
Mg_2Si diffuse into aluminium on the
they have very different diffusion
(a cast binary) alloy Cu Mg_2Si, diffusion
also takes place in the stoichiometric
reactions of the separate metals
the velocity of diffusion of the
when present in the stoichiometric
atomic ones, through the lattice
does not exclude the existence in the
compounds such as Mg_2Si and Mg_2Sn in alloys
Fe in γ Fe. The diffusion of
and Ni into Armco iron
conclusions.

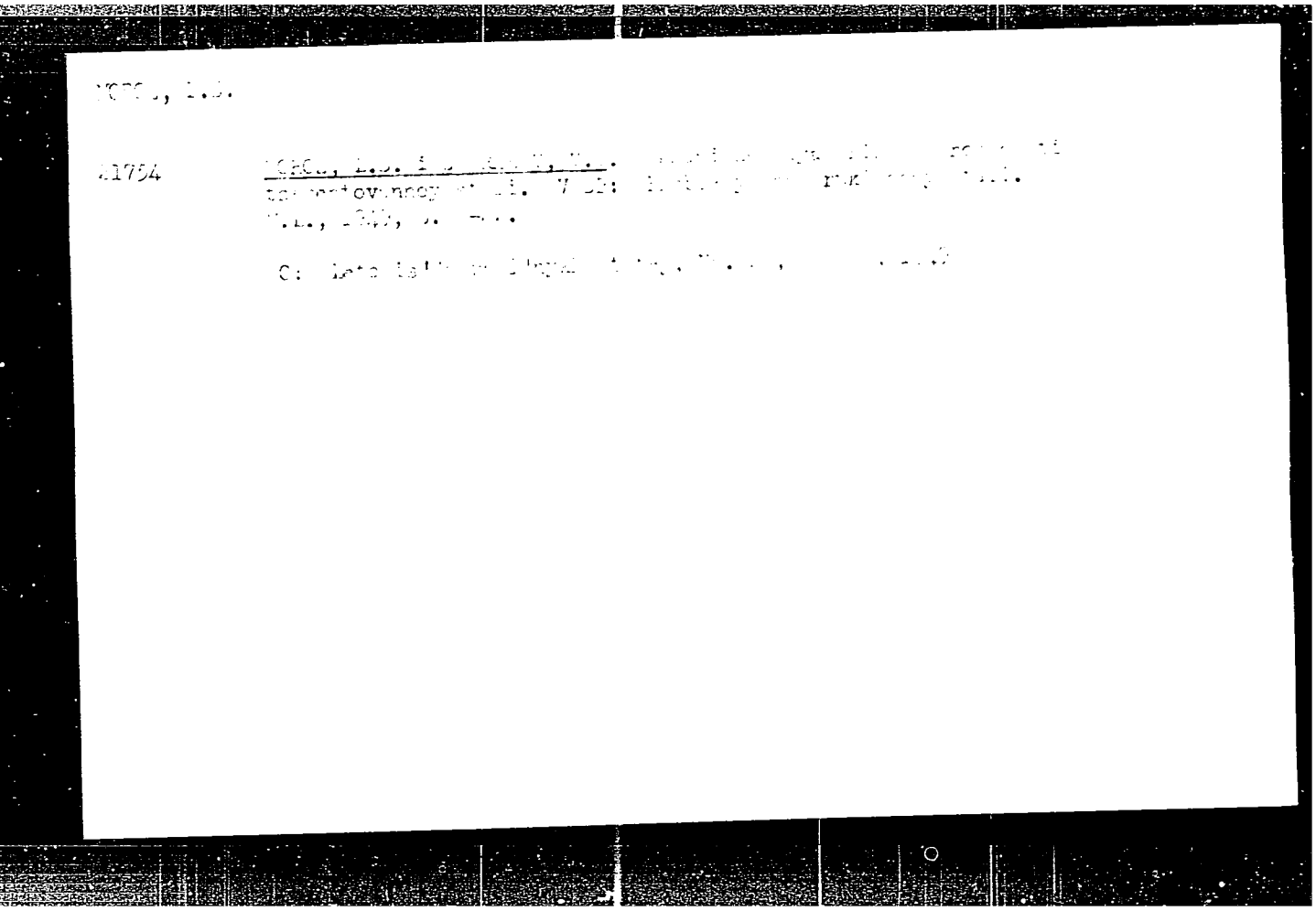
1942

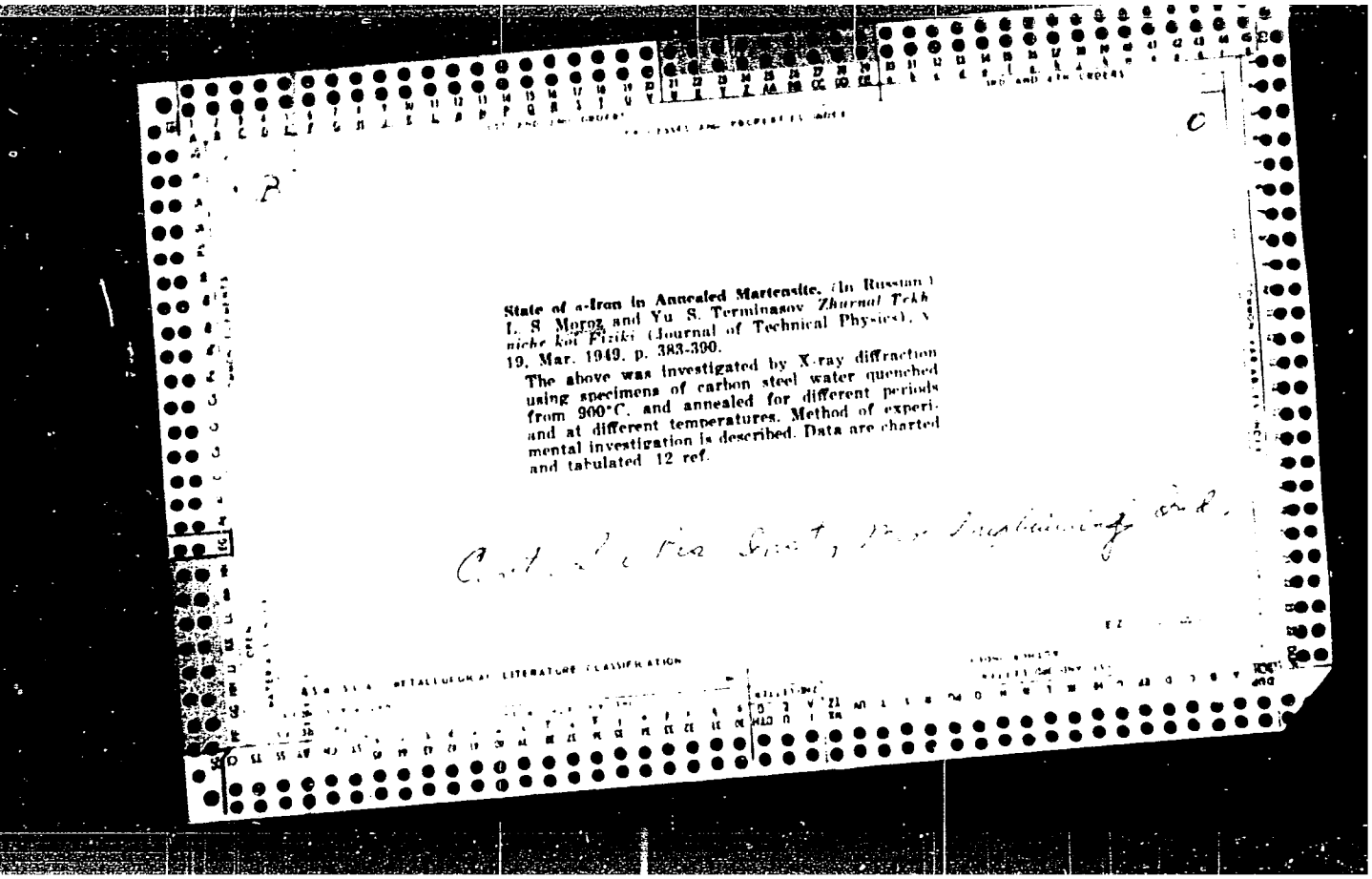


Mechanism of the effect of high annealing on the hardness of steel. L. S. Moroz. *J Tech. Phys* (U.S.S.R.) 16, 171-80(1946). On samples of 5 different carbon steels, 14 × 14 × 10 mm., quenched in 10% NaOH soln. at 4-8°, annealed, the Brinell hardness B (in mm., at a load of 3000 kg.) plotted against the carbon content (0.12 to 0.48%) shows linear increase of B with %C at any given annealing temp t. Parallel straight lines are obtained for various ts, example (from graph): 2 hrs.' annealing at 400, 480, 600, 670°, resp., for 0.12% C, B = 3.5, 3.7, 4.1, 4.5 mm., resp.; for 0.48% C, B = 3.15, 3.4, 3.85, 4.2 mm., resp. Since it was shown by x-ray investigations that the C content of the α-phase on annealing at a const. t above 400°, does not depend on the total %C of the steel, the linear increase of B with %C is due to the carbide phase. The variation of B as a function of %C consists in a change of the resistance to deformation of the α grains as an effect of the amt. of carbide. Extrapolation of the B-%C lines to 0% C gives the hardness of the homogeneous α phase, the error involved in the assumption of a disappearance of the carbide at strictly %C = 0 being of little significance: if the carbide phase disappeared at 0.1% C instead of at 0% C, the hardness of α (annealed at 400°) would be 3.52 mm. as against 3.65 mm. extrapolated to 0% C. Direct detn. of the hardness of the ferrite, by way of decarbonation (8 × 8 × 4 mm. samples in a stream of humid H_2 at 950° for 18 hrs., from 0.12, 0.29, and 0.48% C down to 0.083%), gives the same B = 3.5 mm. as extrapolation to 0% C of steels tempered and slowly cooled. That the linearity of B as a function of %C holds down to the very lowest C content is shown on 0.04% C steel samples, annealed for 2 hrs. at 400, 480, 600, 670°, B = 3.6, 3.8, 4.15, 4.55 mm., resp., the same steel tempered and normalized, B = 5.6. The parallelism of the B-%C lines proves that the mechanism of the effect of C content on the hardness does not vary with t, in other words, the hardness is not detd. by the dispersity of the carbide, if that were so, the 400° line, corresponding to the higher dispersity of the carbide, would have to be steeper than the 670° line, whereas actually they are parallel. Variation of the hardness of carbon steel of a given C content, in terms of t, is due entirely to a change in the properties of the α solid soln. The B-%C lines remain parallel if the duration of the annealing is varied between 45 min. and 100 hrs., at each t, protracted annealing only shifts the line parallel to itself to lower



rdnesses. Consequently, the exaggerated [illegible] which occurs on 100 hrs' annealing at both 450° and 500° does not alter the nature of the variation of B in terms of C; the observed shift must again be ascribed to the α phase. In the space diagram B, t, C, change of B in the B-C plane is detd. solely by the carbide phase, in the B-t section solely by a change of properties of the α phase. Evidently, the diam. of the carbide particles attains a critical value on annealing above 400°, dispersity can only be a detg. factor at annealing temp. below 400°. It must be concluded that the decompn. of martensite is not completed at 350-400° as is commonly assumed, but continues up to 670°. N. Thon





State of α-Iron in Annealed Martensite. (In Russian) L. S. Moroz and Yu. S. Terminasov. *Zhurnal Tekh. Fiziki* (Journal of Technical Physics), v. 19, Mar. 1949. p. 383-390.

The above was investigated by X-ray diffraction using specimens of carbon steel water quenched from 900°C. and annealed for different periods and at different temperatures. Method of experimental investigation is described. Data are charted and tabulated. 12 ref.

PHASE I TREASURE ISLAND BIBLIOGRAPHICAL REPORT AID 353 - I

Call No.: TN672.V8

BOOK

Author: MOROZ, L. S.
Full Title: STRENGTHENING OF ALLOYED IRON IN THE PHASE TRANSFORMATION
Transliterated Title: Uprochneniye legirovannogo zheleza pri fazovom prevrashchenii

Publishing Data

Originating Agency: All-Union Scientific Engineering and Technical Society of Machine Builders. Urals Branch
Publishing House: State Scientific and Technical Publishing House of Machine Building Literature ("Mashgiz")
Date: 1950 No. pp.: 11 No. of copies: 3,000

Text Data

This is an article from the book: VSESOYUZNOYE NAUCHNOYE INZHENERNO-TEKHNICHESKOYE OBSHCHESTVO MASHINOSTROITELEY. URAL'SKOYE OTDELENIYE, THERMAL TREATMENT OF METALS - Symposium of Conference (Termicheskaya obrabotka metallov, materialy konferentsii) (p.225-235) see AID 223-II

Coverage: Substantial increase of hardness of practically carbonless alloyed iron at tempering is discussed. The experimental results indicate that the hardening of α-iron crystals occurs because of deformation at volume change in the process of phase transformation of γ Fe $\rightarrow$ α Fe. The appearance of residual stresses in the crystal lattice and the breaking up

of the grains create the strengthening of alloyed iron which is the substance of "phase hardening".

Comparison of physico-mechanical properties obtained by the phase and mechanical hardening leads to the important conclusion that the strengthening of alloyed iron at plastic deformation and heat treatment is subjected to the same laws of mechanics of materials. However, the mechanical state of crystal lattice at "phase hardening" has a special nature.
10 charts, 2 tables.

Purpose: For scientific workers
Facilities: None
No. of Russian and Slavic References: 5 Russian (1941-49)
Available: Library of Congress

MOROZ, L. S.

Metallography

Causes for the diffusion of interference lines on X-ray plates of carbened carbon-free alloys of iron. Zhur. tekh. fiz. 22 no. 8, 1952

9. Monthly List of Russian Accessions, Library of Congress, August 1952, Uncl.

FD 364

MOROZ, L.S.
USSR/Physics - Alloys, Plasticity

Card 1/1

Author : Moroz, L. S.

Title : Significance of plasticity characteristics, reflecting certain sides of the physical state of alloys

Periodical : Zhur. tekh. fiz. 24, 425-432, Mar 1954

Abstract : Experimentally establishes expediency of considering separately uniformly-distributed and concentrated deformations of alloys under tension and discusses significance of each kind of deformation in investigation of various factors which have effect on physical conditions of alloys. Studies deformations of carbon steel and its characteristics, such as yield point, tensile strength and reduction in area, versus chemical composition, structure and heat treatment. Fifteen references, all USSR; most 1948-1952. Graphs.

Institution :

Submitted : September 18, 1953

MOROZ, L. S.
USSR/Metals - Hardening

FD-442

Card 1/1 : Pub. 153 - 12/18

Author : Moroz, L. S.

Title : The phenomenon of internal cold hardening during the polymorphic conversion of gamma-Fe to alpha-Fe

Periodical : Zhur. tekh. fiz. 24, 705-714, Apr 1954

Abstract : Investigates the influence of volumetric variations, during the polymorphic conversion of gamma-iron to alpha-iron, upon the internal structure and mechanical properties of alloys. Attempts to connect the toughening caused by cold hardening of the alpha-iron crystals, following the changes in volume during the conversion of gamma-Fe to alpha-Fe, with the changes in the mosaic structure of the alloys.

Institution : --

Submitted : September 18, 1953

AL'TGAUZEN, O.N., kandidat fiziko-matematicheskikh nauk; BERNSHTEYN, M.L., kandidat tekhnicheskikh nauk; BLANTER, M.Ye., doktor tekhnicheskikh nauk; BOKSHTEYN, S.Z., doktor tekhnicheskikh nauk; BOLKHOVITINOVA, Ye.N., kandidat tekhnicheskikh nauk; BORZDYKA, A.M., doktor tekhnicheskikh nauk; BUNIN, K.P., doktor tekhnicheskikh nauk; VINOGRAD, M.I., kandidat tekhnicheskikh nauk; VOLOVIK, B.Ye., doktor tekhnicheskikh nauk [deceased]; GAMOV, M.I., inzhener; GELLER, Yu.A., doktor tekhnicheskikh nauk; GORELIK, S.S., kandidat tekhnicheskikh nauk; GOL'DENBERG, A.A., kandidat tekhnicheskikh nauk; GOTLIB, L.I., kandidat tekhnicheskikh nauk; GRIGOROVICH, V.K., kandidat tekhnicheskikh nauk; GULYAYEV, B.B., doktor tekhnicheskikh nauk; DOVGALEVSKIY, Ya.M, kandidat tekhnicheskikh nauk; DUDOVTSEV, P.A., kandidat tekhnicheskikh nauk; KIDIN, I.N., doktor tekhnicheskikh nauk; KIPNIS, S.Kh., inzhener; KORITSKIY, V.G., kandidat tekhnicheskikh nauk; LANDA, A.F., doktor tekhnicheskikh nauk; LEYKIN, I.M., kandidat tekhnicheskikh nauk; LIVSHITS, L.S., kandidat tekhnicheskikh nauk; L'VOV, M.A., kandidat tekhnicheskikh nauk; MALYSHEV, K.A., kandidat tekhnicheskikh nauk; MEYERSON, G.A., doktor tekhnicheskikh nauk; MINKEVICH, A.N., kandidat tekhnicheskikh nauk; MOROZ, L.S., doktor tekhnicheskikh nauk; NATANSON, A.K., kandidat tekhnicheskikh nauk; NAKHIMOV, A.M., inzhener; NAKHIMOV, D.M., kandidat tekhnicheskikh nauk; POGODIN-ALEKSEYEV, G.I., doktor tekhnicheskikh nauk; POPOVA, N.M., kandidat tekhnicheskikh nauk; POPOV, A.A., kandidat tekhnicheskikh nauk; RAKHSHTADT, A.G., kandidat tekhnicheskikh nauk; ROGEL'BERG, I.L., kandidat tekhnicheskikh nauk;

(Continued on next card)

AL'TGAUZEN, O.N.---- (continued) Card 2.
SADOVSKIY, V.D., doktor tekhnicheskikh nauk; SALTYKOV, S.A., inzhener; SOBOLEV, N.D., kandidat tekhnicheskikh nauk; SOLODKHIN, A.G., kandidat tekhnicheskikh nauk; UMANSKIY, Ya.S., kandidat tekhnicheskikh nauk; UTEVSKIY, L.M., kandidat tekhnicheskikh nauk; FRIDMAN, Ya.B., doktor tekhnicheskikh nauk; KHIMYSHIN, F.F., kandidat tekhnicheskikh nauk; KHRUSHCHEV, M.M., doktor tekhnicheskikh nauk; CHERNASHKIN, V.G., kandidat tekhnicheskikh nauk; SHAPIRO, M.M., inzhener; SHKOL'NIK, L.M., kandidat tekhnicheskikh nauk; SHRAYBER, D.S., kandidat tekhnicheskikh nauk; SHCHAPOV, N.P., doktor tekhnicheskikh nauk; GUDTSOV , N.T., akademik, redaktor; GORODIN, A.M. redaktor izdatel'stva; VAYNSHTEYN, Ye.B., tekhnicheskiy redaktor

[Physical metallurgy and the heat treatment of steel and iron; a reference book] Metallovedenie i termicheskaia obrabotka stali i chuguna; spravochnik. Pod red. N.T.Dudtsova, M.L.Bernshteina, A.G. Rakhshtadta. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po chernoi i tsvetnoi metallurgii, 1956. 1204 p. (MLRA 9:9)

1. Chlen -korrespondent Akademii nauk USSR (for Bunin)
(Steel--Heat treatment) (Iron--Heat treatment)
(Physical metallurgy)

MOROZ, Lev Solomonovich, LAKHTIN, Yu.M., redaktor; VALOV, N.A., redaktor izdatel'stva; EVENSON, I.M., tekhnicheskiy redaktor

[Fine structure and the strength of steel] Tonkaia struktura i prochnost' stali. Moskva, Gos. nauchno-tekhn. izd-vo lit-ry po chernoi i tsvetnoi metallurgii, 1957. 158 p. (MLRA 10:6)
(Steel--Metallography)

SOV [illegible]

Translation from Referativnyy zhurnal. Metallurgiya [illegible] No 12 p 15. USSR.

AUTHORS Moroz L S Kresin Yu D Morgun T E Chernetsov V I

TITLE The Strength of Titanium (Prochnost' titana)

PERIODICAL V sb Metallurgiya Moscow-Leningrad AN SSSR 1957 pp 172-193

ABSTRACT An investigation was made of the effect of low temperatures rate and length of loading time notching and other external factors on the modulus of rupture of industrial Ti smelted in an electric-arc vacuum furnace The authors discovered a sharp difference in sensitivity to notching (SN) in metals of separate smeltings which was determined by the ratio between the specific deformation work of impact stretching of smooth specimens and the a_k of notched Mesnager-type specimens. Ti which has a high SN is also sensitive to the state of the surface in notched specimens The maximum H content of 0.007 - 0.008% with which Ti retains a tolerable SN but this figure may vary depending upon O and N content The intensity of the effect of H on the a_k is determined by the size and type of Ti-H precipitation which depends upon the cooling rate from the temperature of >400°C Static

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bending tests of notched specimens showed that the magnitude of the bending deflection and the deformation work up to the appearance of the first crack, as well as the work of propagation of the crack through the entire section of the specimen at room temperature, are less in Ti than in SKhL-4 steel. In dynamic testing Ti with 0.0007% H exhibits no cold-brittleness whatever, but when affected by impurities, in particular by H, it becomes cold-brittle. An increase in H content to 0.0125% decreases σ by 75% at -196°C. The authors advance a hypothesis to explain the physical nature of H-brittleness of Ti by the low S_{or} of favorably oriented hydride inclusions. It was discovered that the strain rate has no effect on the ductility of smooth specimens of Ti enriched with H.

G T

Moroz, L. S.

AUTHORS: Moroz, L. S., Dr. Tech. Sc.; Nemchinskiy, A. L., Cand. Tech. Sc.; Pashkov, P. O., Dr. Tech. Sc., Prof., Shurakov, S. S., Cand. Tech. Sc.; and Bendryshev, O. L., Cand. Tech. Sc., Head of the Central Factory Laboratory (Tsentral'naya zavodskaya laboratoriya)

TITLE: Brittle Breakdown of Steel and Steel Parts (Khrupkiye razrusheniya stali i stal'nykh detaley)

PERIODICAL: Zavodskaya Laboratoriya, 1957, Vol. 23, No. 1, pp. 123-125 (U.S.S.R.)

ABSTRACT: The first four of the above authors present a review of the book, "Brittle Breakdown of Steel and Steel Parts" by Ya. M. Potak, which contains 389 pages and is published by OBORONGIZ, dated 1955. These critics find that the author used much material based on his own investigations. They state that the book fills a need in the metallurgical industry and contains little that merits criticism. The author listed last above, Bendryshev, makes a separate review and finds that the book will acquaint wide circles of

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Moroz, L.S.

18(7) PHASE I BOOK EXPLOITATION SOV/1636

Metallovedeniye; sbornik statey, [vyp.] 2 (Study of Metals; Collection of Articles, [Nr] 2) [Leningrad] Sudpromgiz, 1958. 265 p. 4,000 copies printed.

Resp. Ed.: G.L. [illegible], Candidate of Technical Sciences; Ed.: Ye. A. Krugova; Tech. Ed.: K.M. Volchok.

PURPOSE: This book is intended for metallurgists and metallurgical engineers.

COVERAGE: This is the second volume of collected scientific papers dealing with various problems in physical metallurgy, particularly in mechanical metallurgy and metallography. Topics covered include hydrogen embrittlement, intragranular distribution of elements in alloys, effect of tempering on carbon redistribution, use of tritium to investigate certain phenomena in metals, effect of certain alloying elements on temper brittleness and hardenability of steel, strength of notched specimens of brittle steel, effect of strain hardening on the properties of an aluminum alloy, etc. The articles are concerned mainly with various types of steel, though some deal with nonferrous alloys.

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Study of Metals (Cont.) SOV/1636

Numerous Soviet and non-Soviet references are included.

TABLE OF CONTENTS:

Moroz, L.S., Doctor of Technical Sciences, and T.E. Mingin, Engineer. Hydrogen Embrittlement of Steel

In their investigation the authors studied the causes of hydrogen embrittlement, the effect of hydrogen on mechanical properties, the condition of hydrogen in the crystal lattice, retarded failure of hydrogen-saturated steel, and the effect of hydrogen on the deformation and failure of ductile steel under tension. Their experimental data support the hypothesis that hydrogen embrittlement is caused by molecular hydrogen collecting under pressure in microscopic interstices in the metal. However, present-day theories, according to which hydrogen embrittlement develops only in the process of deformation and can be inhibited by lowering the temperature or increasing the speed of deformation, were not borne out by the experiments. The authors believe that when the hydrogen content is sufficiently high, the pores in the metal are filled with molecular hydrogen under high pressure, which is intensified during deformation by the application of external forces, leading to local ruptures, or cracks.

Moroz, L.S.

Akademiya nauk SSSR

Nekotoryye problemy prochnosti tverdogo tela; sbornik statey (Some Problems in the Strength of Solids; Collection of Articles) Moscow, Izd-vo AN SSSR, 1959. 386 p. Errata slip inserted. 2,000 copies printed.

Ed. of Publishing House: V. I. Aver'yanov; Tech. Ed.: R. S. Pevzner; Editorial Board: A.F. Ioffe, Academician; G. V. Kurdyumov, Academician; S. N. Zhurkov, Corresponding Member, USSR Academy of Sciences; B. P. Konstantinov, Corresponding Member, USSR Academy of Sciences; F. F. Vitman, Doctor of Physical and Mathematical Sciences, Professor (Resp. Ed.); L. A. Glikman, Doctor of Technical Sciences, Professor; N. A. Zlatin, Doctor of Physical and Mathematical Sciences; V. A. Stepanov, Doctor of Technical Sciences; Ya.B. Fridman, Doctor of Technical Sciences, Professor; B. S. Ioffe, Candidate of Technical Sciences (Deputy Resp. Ed.).

PURPOSE: This book is intended for construction engineers, technologists, physicists and other persons interested in the strength of materials.

COVERAGE: This collection of articles was compiled by the Otdeleniye fiziko-matematicheskikh nauk AN SSSR (Department of Physical and Mathematical Sciences) and the Fiziko-tekhnicheskiy institut AN SSSR (Institute of Applied Physics, Academy of Sciences, USSR) in commemoration of the 80th birthday of Nikolay Nikolayevich Davidenkov, Member of the Ukrainian Academy of Sciences, founder and head of the Otdel prochnosti materialov (Department of the Strength of Materials) at the Institute of Applied Physics, Academy of Sciences, USSR, founder of the Fakul'tet fizicheskogo metallovedeniya (Department of Physical Metallurgy) at the Leningradskiy politekhnicheskiy institut (Leningrad Polytechnic Institute), recipient of the Stalin Prize (1943), the Order of the Red Banner of Labor (1945) and the Order of Lenin (1953). The articles deal with the strength of materials, phenomena of imperfect elasticity, temper brittleness, hydrogen embrittlement, cold brittleness, influence of deformation speed on the mechanical properties of materials, fatigue of metals, and general problems of the strength, plasticity, and mechanical properties of nonmetals. Numerous personalities are mentioned in the introductory profile of Professor Davidenkov. References are given at the end of each article.

MOROZ, L.S., doktor tekhn.nauk; MIGIN, T.E., inzh.

Mechanism of the hydrogen embrittlement of steel. Metallovedenie 3:51-57 '59. (MIRA 14:3)
(Steel--Hydrogen content)

MOROZ, L.S., doktor tekhn.nauk; KHESIN, Yu.D., inzh.

Study of the mechanism of hydrogen embrittlement of titanium and its alloys. Metallovedenie 3:74-87 '59. (MIRA 14:3)
(Titanium—Hydrogen content)

MOROZ, L.S., doktor tekhn.nauk; KHESIN, Yu.D., inzh.

Anomalous metal grain growth in vacuum. Metallovedenie 3:312-313 '59. (MIRA 14:3)

(Vacuum metallurgy)
(Metal crystals--Growth)

Moroz L. S.

PHASE I BOOK EXPLOITATION SOV/3752

Metallovedeniye; sbornik statey, No. 3 (Physical Metallurgy; Collection of Articles, No. 3), Leningrad, Sudpromgiz, 1959. 320 p. 3,200 copies printed.

Ed.: G. L. Kapyrin, Candidate of Technical Sciences; Literary and Tech. Ed.: N. I. Doronenko.

PURPOSE: This collection of articles is intended for scientific personnel at research and educational institutions and industrial plants and also for advanced students.

COVERAGE: The articles report the results of investigations of 1) the effect of various factors on the susceptibility of constructional and heat-resistant steels and titanium alloys to brittle failure at various temperatures under various conditions of loading (long-time, short-time, cyclic, noncyclic) 2) alloying, structure, and condition of alloys as related to their mechanical properties, and 3) corrosion resistance and evaluation of stainless and heat-resistant steels. The articles are accompanied by numerous Soviet and non-Soviet references. No personalities are mentioned.

PHASE I BOOK EXPLOITATION SOV/4573

Moroz, Lev Solomonovich, Doctor of Technical Sciences, Professor; Boris Borisovich Chechulin, Ivan Vasil'yevich Polin, Leonid Vladimirovich Butalov, Saveliy Moiseyevich Shul'kin, and Aleksandr Petrovich Goryachev

Titan i yego splavy, tom 1: Tekhnicheski chistyy titan (Titanium and Its Alloys, Vol. 1: Commercially Pure Titanium) Leningrad, Sudpromgiz, 1960. 515 p. Errata slip inserted. 4,200 copies printed.

Ed. (Title page): L.S. Moroz; Ed. (Inside book): Z.V. Vlasova; Tech. Ed.: N.V. Erastova.

PURPOSE: This book is intended for scientific workers, plant engineers, and students in advanced courses in schools of higher technical education and tekhnikums. It may also be used as a manual for designers and industrial engineers (with the exception of mechanical engineers).

COVERAGE: The book presents data on the structure, phase transformation, and physicochemical and processing properties of commercially pure titanium.

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Shape-casting, vacuum metallurgy, plastic deformation, welding, and soldering and brazing processes for titanium are discussed. Special attention is given to problems of constructional strength and to titanium reduction processes. L.S. Moroz wrote section 1 of Chapter 1, Chapter 2, and sections 1, 4, and 6 of Chapter 3. B.B. Chechulin wrote sections 2-6 of Chapter 1, sections 2, 3, and 5 of Chapter 3, and Chapters 4 and 9. I.V. Polin wrote Chapter 5; L.V. Butalov, Chapter 6; S.M. Shul'kin, Chapter 7; and A.P. Goryachev, Chapter 8. The authors thank A.V. Smirnov for his advice, and I.A. Bytenskiy for assistance in editing the manuscript. References accompany each chapter.

TABLE OF CONTENTS:

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E193/E135

AUTHORS: Moroz, L.S., and Khesin, Yu.D. (Leningrad)

TITLE: Investigation of the Mechanism of Hydrogen Embrittlement of Titanium and its Alloys

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1960, Nr 1, pp 111-122 (USSR)

ABSTRACT: The object of the present investigation was to study the effect of hydrogen on the mechanical properties of α-Ti and titanium alloys of the β and α+β type (the constitution diagram of the Ti-H system is reproduced in Fig 1; wt-%, top scale, at-%, bottom scale). The experimental materials comprised: technical purity Ti (U.T.S. = 55 kg/mm^2 at room temperature); a two-phase, Ti-base alloy containing 2% Mn, 1.3% Fe, 0.8% Cr, 1.2% Mo and 1.2% V; a two-phase, Ti-base alloy containing 5% Al, 3% Mo and 3% V; and a β-alloy, containing 15% Mo. After hot working, all these alloys were finely-crystalline with the average grain size of 0.04 to 0.07 mm, after a vacuum treatment (15 h at 700°C) their hydrogen content was less than 0.003%. Two methods were used to introduce hydrogen into the test pieces that were to be employed in the subsequent tests: the

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Investigation of the Mechanism of Hydrogen Embrittlement of Titanium and its Alloys

electrolytic and high-temperature diffusion method. The electrolytic treatment was carried out in a 0.1 N H_2SO_4 solution, containing 20 mg As_2O_3/litre, at a current density of 0.2 amp/cm^2. After 2 h treatment, the concentration of hydrogen in the specimen varied from about 0.2 wt-% in the surface layer to 0.1% at a distance of 0.1 mm from the surface, and 0.01% at a distance of 0.2 mm from the surface. The high-temperature diffusion treatment was carried out at 700 °C, hydrogen being obtained by decomposition of titanium hydride; after the diffusion treatment the test piece was heated and, to avoid the effects of ageing, the mechanical tests were conducted within 24 h. To determine the effect of heat treatment on the constitution of the alloy, the effect of the quenching temperature on the structure of the $\alpha+\beta$ alloys was investigated with the aid of X-ray diffraction technique. The results are reproduced in Table 1, showing: quenching temperature, °C; proportion (%) of the β-phase in alloy Nr 1 and Nr 2 (for composition see

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Investigation of the Mechanism of Hydrogen Embrittlement of Titanium and its Alloys

the heading of the table). The effect of hydrogen on the mechanical properties of the technical purity titanium, annealed at 650 °C, is illustrated by data given in Table 2 under the following headings: H_2 content, wt-%; σ_s (yield point, kg/mm^2); ψ (reduction of area, %); a_k (impact strength, kg/mm^2). It will be seen that whereas neither the yield point nor ductility (as indicated by ψ) of the specimens were affected by increasing hydrogen concentration, the impact strength, determined on notched bars, failed catastrophically. This effect is a direct consequence of the nature of the Ti-H constitution diagram (Fig 1). Solubility of H in α-Ti varies from 0.18 at 300 °C to 0.002 wt-% at 100 °C; after slow cooling from temperatures above 300 °C, hydrogen is present in titanium in the form of fully precipitated titanium hydride platelets (see the photomicrograph, Fig 2); when titanium, containing less than 0.18 wt-% H_2, is heated to 300 °C, hydrides dissociate completely and a solid solution of H in Ti is formed. On quenching from this or a higher temperature, a super-saturated, precipitation-hardenable,

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Investigation of the Mechanism of Hydrogen Embrittlement of Titanium and its Alloys

solid solution will be obtained. Thus, a titanium specimen with 0.03% H, quenched from 500 °C, had an impact strength of 7 kgm/cm^2; after ageing at 200 °C its impact strength decreased to 1 kgm/cm^2. Similar results could be obtained by prolonged room temperature ageing; this is illustrated by data, given in Table 3, which shows values of a_k of the H-bearing Ti specimen after quenching from 500 °C, and after 1, 10 and 100 days' ageing at room temperature. Electron-microscope study of the ageing process confirmed the hypothesis that, in this case, embrittlement during ageing is associated with the precipitation and coalescence of titanium hydrides; this is illustrated clearly by the photomicrographs (X 2350) reproduced in Fig 3 (a - the microstructure of an H-bearing, Ti specimen in the quenched condition, b - the same microsection after 7 days' ageing at room temperature) which show the increased proportion of the hydrides as well as the grain-boundary broadening in the aged material. Regarding the mechanism of the embrittling

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effect of hydrides, the authors base their considerations on the experimental data reproduced in Tables 4 and 5. The effect of the rate of deformation on ductility of annealed, H-bearing, α-Ti is illustrated in Table 4, which shows: H_2 content, wt-%; elongation (δ, %) and reduction of area (ψ, %) for specimens, tested at the rates of strain of: (I) 2 mm/min, and (II) 2.10^5 mm/min. The effect of the test temperature on the ductility of the same material is illustrated in Table 5, showing: H_2 content, wt-%, δ, and ψ determined at +20, -20 and -60 °C; (the specimen with 0.03% H tested at -60 °C failed in a brittle manner). It can be inferred from data given in Tables 2, 4 and 5 that brittleness due to hydrogen is not revealed by standard tensile tests, conducted on cylindrical specimens, and only becomes evident in the presence of a notch, at high rates of strain, or at low temperatures. These facts can be interpreted in one way only: titanium hydrides, while possessing some ductility, have low resistance to rupture, if the normal tensile stress in titanium is lower than the rupture strength of

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the hydrides, the effect of hydrogen will not become apparent; if the normal stress is raised above that critical value (by introduction of a notch, increasing the strain rate, or lowering the temperature), cracks are formed in the hydrides which reduce the strength of the metal to a level depending on the proportion of hydride platelets present and on their size, since these factors determine the number and dimensions of the cracks. This is illustrated by data reproduced in Fig 4, where the true tensile strength (S_K, kg/mm^2) of H-bearing titanium at -196 °C is plotted against the quantity and dimensions of the precipitated hydrides, points a, б, and в relating to: (a) specimen quenched from 500 °C (low hydride concentration); (б) specimen quenched and aged for 2 h at 100 °C (medium concentration of hydrides of small size); (в) specimen annealed at 400 °C (high concentration of coarse hydride particles). The propagation of cracks in hydrogen-embrittled titanium is assisted by the internal tensile stresses. present at the

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edges of the hydride platelets owing to their higher (in comparison with Ti) specific volume. Oxygen, nitrogen, and carbon additions increase the sensitivity of titanium to hydrogen embrittlement, since they promote propagation of cracks; the effect of aluminium is beneficial since this metal increases solubility of hydrogen in titanium. The effect of hydrogen on the mechanical properties of a β-type, 15% Mo-Ti alloy was studied next. The results are reproduced in Table 6, showing: condition of the alloy (degassed; hydrogen-impregnated by electrolytic treatment - 3 h at 0.2 amp/cm^2); U.T.S. (σ_B, kg/mm^2); yield point (σ_S, kg/mm^2); δ, %; ψ, %. It will be seen that none of the investigated properties were affected by the presence of hydrogen. The results of experiments on specimens with higher content of hydrogen (introduced by high-temperature diffusion), quenched from 750 °C, are given in Fig 5, where ψ of specimens tested at the rates of strain of 2 and 200 mm/min (crosses and circles, respectively) is plotted against the hydrogen content (%).

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It will be seen that as long as hydrogen is in the solution, it does not affect the ductility of the β-phase; precipitation of hydrides in the β-phase causes the metal to fail in a brittle manner, this effect being attributed to notch-sensitivity of the β-phase. The hydrogen embrittlement of the α+β alloys is next discussed. Two alloys of this type, containing 20 and 50% of the β-phase, were investigated. Their mechanical properties (σ_s, δ, and ψ), are given in Table 7, the figures in the first and second sub-columns for each property relating to the hydrogen-free specimens and to specimens subjected to 24 h electrolytic hydrogenization treatment. It will be seen that, whereas the yield point was not affected by the presence of hydrogen, the ductility of the alloy (δ, ψ) decreased sharply. It was observed, also, that fracture of the hydrogen-bearing specimens started at the surface, the first cracks appearing already in the elastic deformation range (see Fig 6). The effect of the

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variation of the content of hydrogen, introduced by high-temperature diffusion, is illustrated by data given in Table 8 under the following headings; H_2 content, wt-%; ψ, %, of the alloy containing 20 and 50% of the β-phase. (A specimen of the alloy, containing 20% of the β-phase and 0.1% H_2, failed in the brittle manner). These results showed that the embrittling effect of hydrogen was more pronounced in the alloy with a lower content of the β-phase. The effect of the deformation rate is illustrated in Figs 7 and 8. In Fig 7a, ψ is plotted against the rate of strain (V, mm/min) for an alloy containing 20% of the β-phase, curves 1 and 2 relating to specimens before and after the electrolytic hydrogenization treatment, respectively; the corresponding curves for the alloy containing 50% of the β-phase are plotted in Fig 7b. In Fig 8a, ψ is plotted against V for the alloy containing 50% of the β-phase, curves 1, 2 and 3 relating to specimens with 0.025, 0.050 and 0.1% of hydrogen (introduced by high-temperature diffusion

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treatment) respectively; the corresponding curves (1 and 3) for the alloy containing 20% of the β-phase are plotted in Fig 8b. In this case, too, the proportion of the β-phase determined the behaviour of the alloys. The ductility of specimens containing hydrogen, introduced electrolytically, increased with increasing V, approaching the ductility of hydrogen-free material at V = 200 mm/min, this restoration of ductility with increasing V being less pronounced in the alloy with 50% of the β-phase. In the case of specimens containing hydrogen introduced by the high-temperature diffusion treatment, the restoration of ductility with increasing V was slow in specimens containing 50% of the β-phase, and did not occur at all in specimens containing 20% of the β-phase and 0.1% H_2. The effect of the constitution on the sensitivity of the α+β alloys to hydrogen embrittlement was revealed also by the results of impact strength tests, conducted on notched, cylindrical specimens 8 mm diameter (depth of

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the notch 1 mm, root radius 0.55 mm). The results of these tests are given in Table 9, showing: H_2 content, wt-%; a_k, kgm/cm^2, of specimens containing 20 and 50% of the β-phase. However, it is pointed out that tensile test at slow rates of strain is a more sensitive method of revealing the hydrogen embrittlement of titanium alloys of the α+β type. The difference in the behaviour of material containing hydrogen, introduced by different techniques, is attributed to the fact that hydrogen introduced electrolytically (i.e. at room temperature) can dissolve in the β-phase only. This was checked by X-ray diffraction analysis, carried out on a complex, Mn-bearing alloy, whose alloying elements, however, did not affect the solubility of hydrogen. The results are given in Table 10 under the following headings: constitution of the alloy (relative proportion of the α- and β-phase); lattice parameters of the α- and β-phases in the degassed alloy; lattice parameters of the α- and β-phases in the alloy with

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