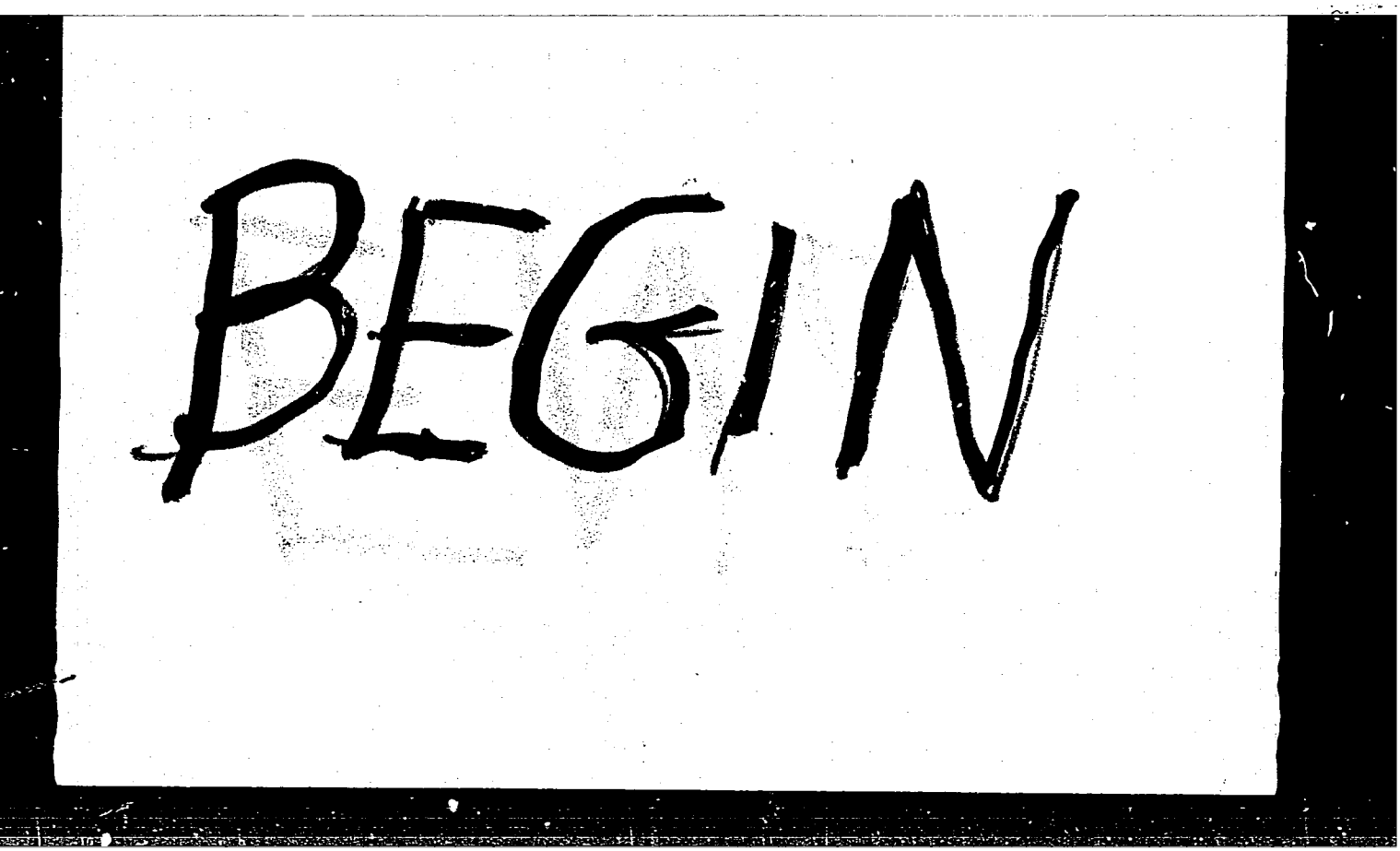
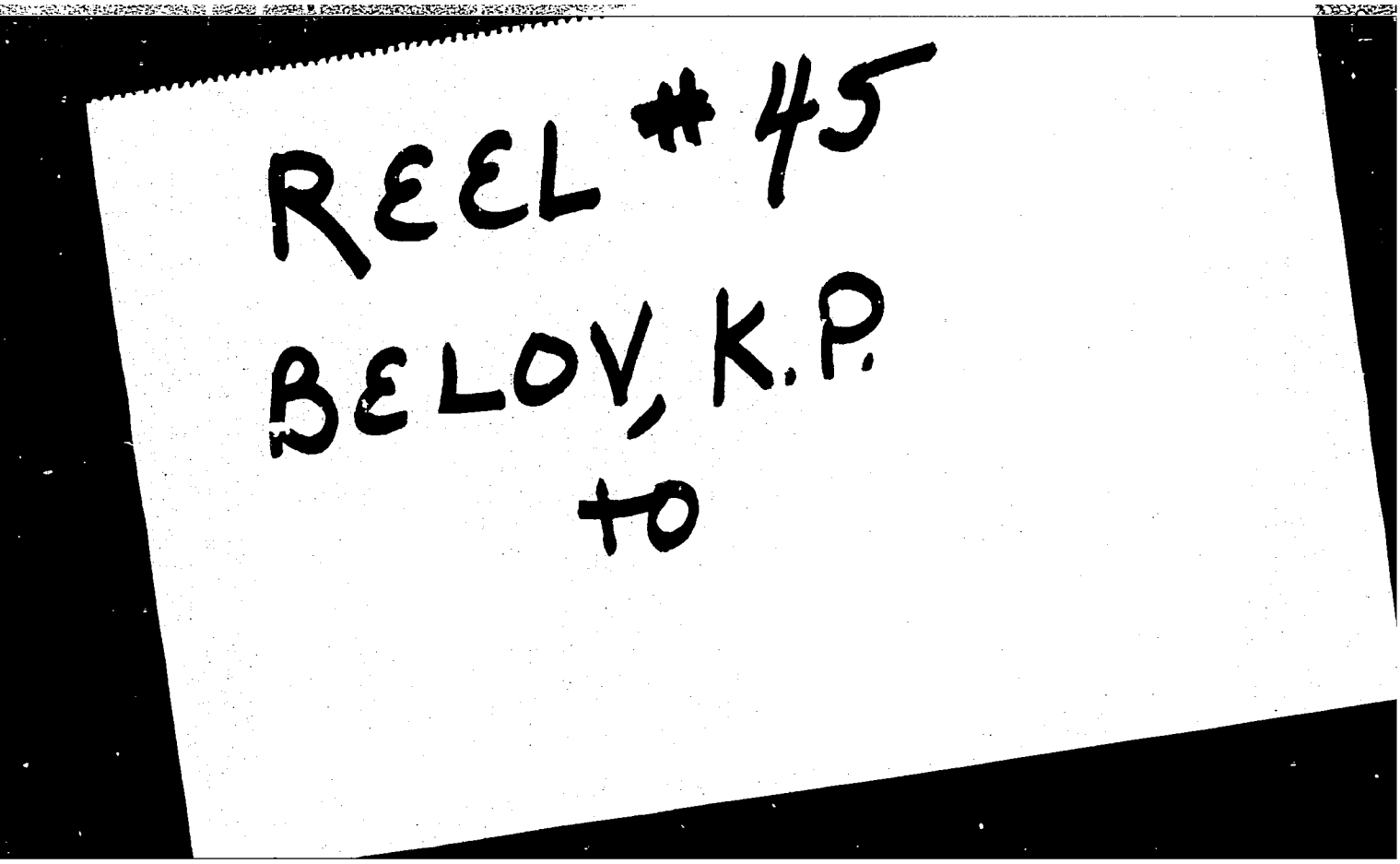
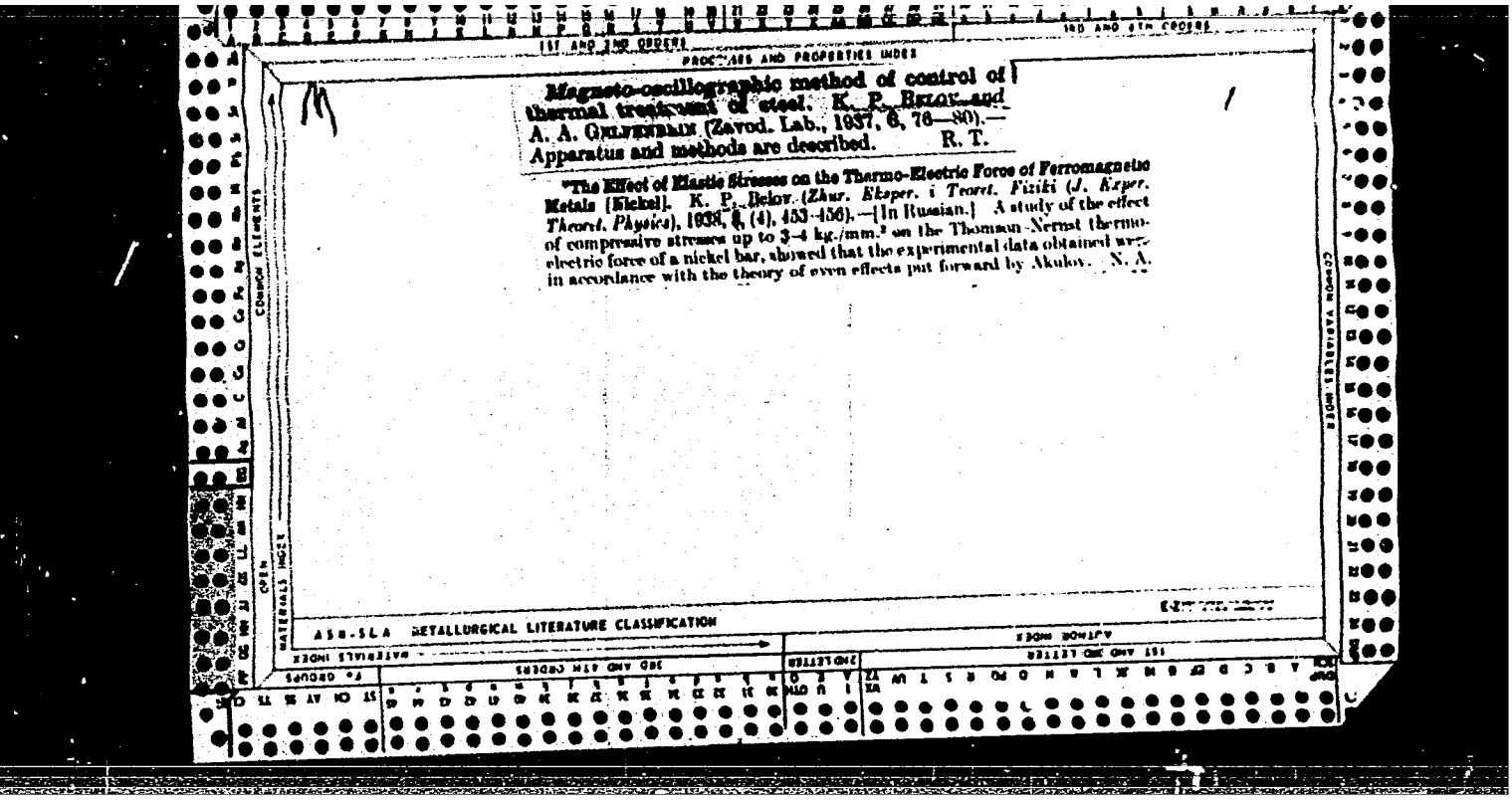






Magneto-oscillographic method of control of thermal treatment of steel. K. P. Belov and A. A. Gulyaev (Zavod. Lab., 1937, 6, 76—80).—Apparatus and methods are described. R. T.

"The Effect of Elastic Stresses on the Thermo-Electric Force of Ferromagnetic Metals [Nickel]. K. P. Belov. (*Zhur. Eksper. i Teoret. Fiziki* (*J. Exper. Theoret. Physics*), 1938, 8, (4), 453–456).—[In Russian.] A study of the effect of compressive stresses up to 3–4 kg./mm.² on the Thomson-Nernst thermo-electric force of a nickel bar, showed that the experimental data obtained were in accordance with the theory of even effects put forward by Akulov. N. A.

MA

Effect of Elastic and Residual Deformations on the Galvanic Effect of Ferromagnetic Materials [Nickel]. K. P. Belov and D. I. Volkov (*Zhur. Tekhnich. Fiziki (J. Tech. Physics)*, 1939, 9, 1529-1539; *Chem. Zentr.*, 1940, 111, (1), 2132).—[In Russian.] In plastic deformation, zones of tensile and of compressive stresses in the metal can be postulated, the magnitude, number, and direction of which depend on the nature of the deformation. B. and V. assume a model of distribution of internal stresses in a nickel wire after plastic deformation, in which tensile and compressive zones alternate periodically in the cross-section. Corresponding to the stress directions, the magnetization vectors lie parallel and vertical to the axis of the wire, this explaining the decrease of galvanomagnetic effect by 25% in drawn nickel compared with annealed soft nickel. Galvanometric and similar effects may serve in general as sensitive indicators of the internal stress distribution in ferromagnetic metals.

Sci. Res. Inst. Physics, Moscow State U.

BELOV, K. P.

PA 57T81

USSR/Phys Nov/Dec 1947
Magnetostriction
Invar

"Temperature Dependence of the Magnetostriction of Invar Alloys," K. P. Belov, O. N. Agasyan, Sci Res Inst Phys, Moscow State U, 6 pp

"Izv Akad Nauk SSSR, Ser Fiz" Vol XI, No 6

Invar, elinvar, kovar, and similar alloys have anomalies of their volume and elastic properties with very complex dependence upon temperature. According to present hypotheses, the nature of these anomalies is clearly connected with the ferromagnetism of these alloys, and primarily determined by

[redacted] 57T81

USSR/Phys (Contd) Nov/Dec 1947

character of flow of the ferromagnetostriction phenomena. This study of magnetostriction of these alloys and especially the dependence upon temperature is of interest since it makes possible determination of the nature of the anomalous properties of Invar-type alloys.

[redacted] 57T81

BELOV, K. P.

PA 57T85

USSR/Phys — Nov/Dec 1947
Ferromagnetism
Invar

"Ferromagnetic Nature of Properties of Invar and Elinvar Alloys," K. P. Belov, Sci Res Inst Phys, Moscow State U, 4½ pp

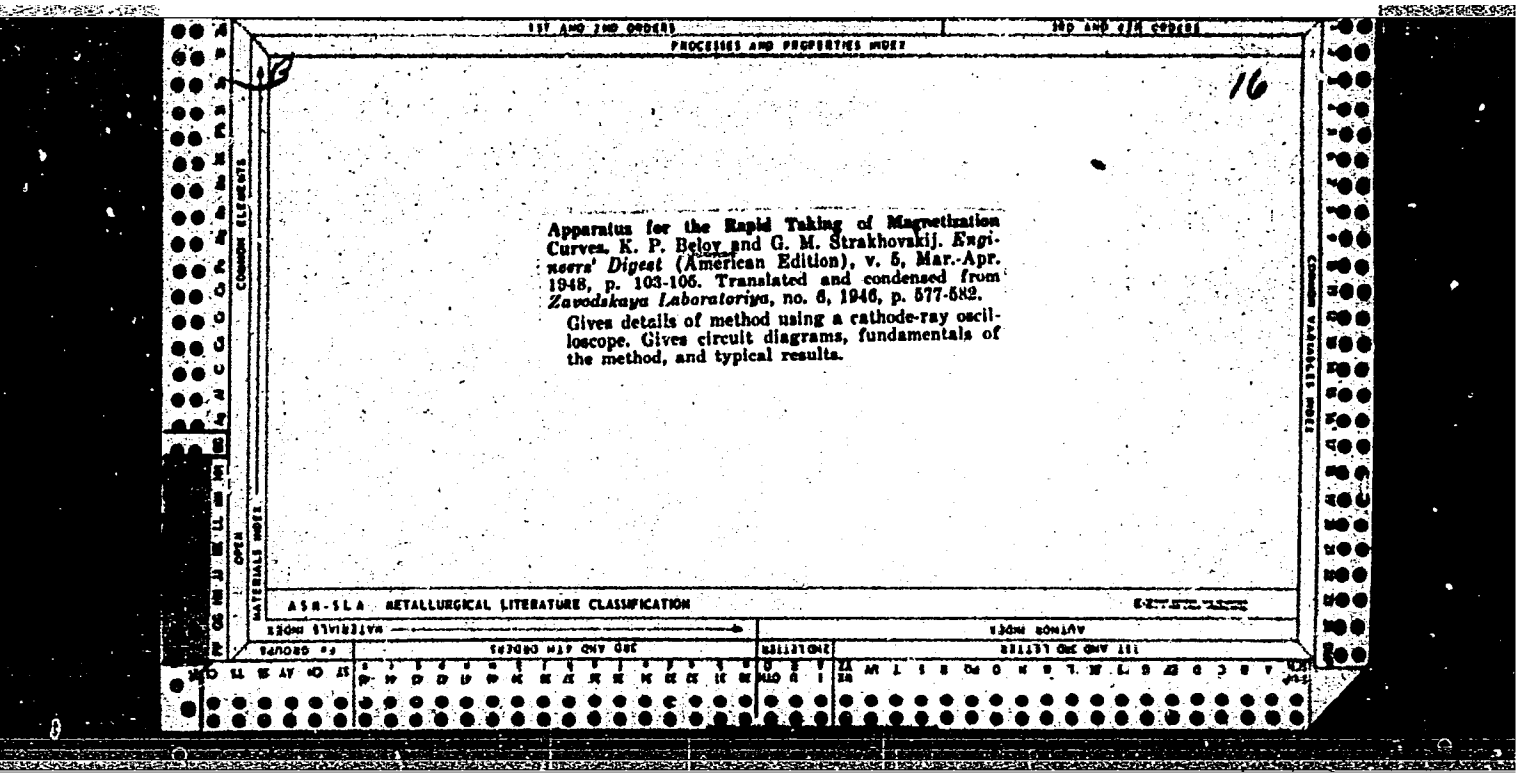
"Izv Akad Nauk SSSR, Ser Fiz" Vol XI, No 6

On the basis of results of this study rational explanation is given of the anomaly of thermal expansion in Invar alloys and of the low temperature coefficient of the modulus of elasticity of elinvar. Using data obtained by measurement of magnetostriction and susceptibility in the paraprocess field,

57T85

correctness of the "ferromagnetic" explanation of the thermal expansion anomaly of Invar is shown.

57T85



16

Apparatus for the Rapid Taking of Magnetization Curves. K. P. Belov and G. M. Strakhovskij. *Engineers' Digest* (American Edition), v. 5, Mar.-Apr. 1948, p. 103-106. Translated and condensed from *Zavodskaya Laboratoriya*, no. 6, 1946, p. 577-582.

Gives details of method using a cathode-ray oscilloscope. Gives circuit diagrams, fundamentals of the method, and typical results.

BELOV, K.P.

Slizade, Z. I. and Belov, K.P. "The effect of elasticity (tension) on the magnetic induction of the Fe-Pt alloy," Vestnik Mosk. un-ta, 1948, No. 9, p. 47-49

SO: U-2388, Letopis Zhurnal'nykh Statey, No. 1, 1949

BELOV, K. P.

Belov, K. P. - Experimental demonstrations of the ferromagnetic nature of anomalies in the thermal expansion of Invar steels," (Paper read at the Lomonsov readings in the Physics Faculty of Moscow University, April 1948), Vestnik Mosk. un-ta, 1948, No. 11, p. 89-94 --- Bibliog: p. 94

So: U-3566, 15 March 53, (Letopis 'Zhurnal 'nykh Statey, No. 13, 1949)

BELOV, K. P.

PA 24/49T116

USSR/Physics
Ferromagnetism
Magnetism

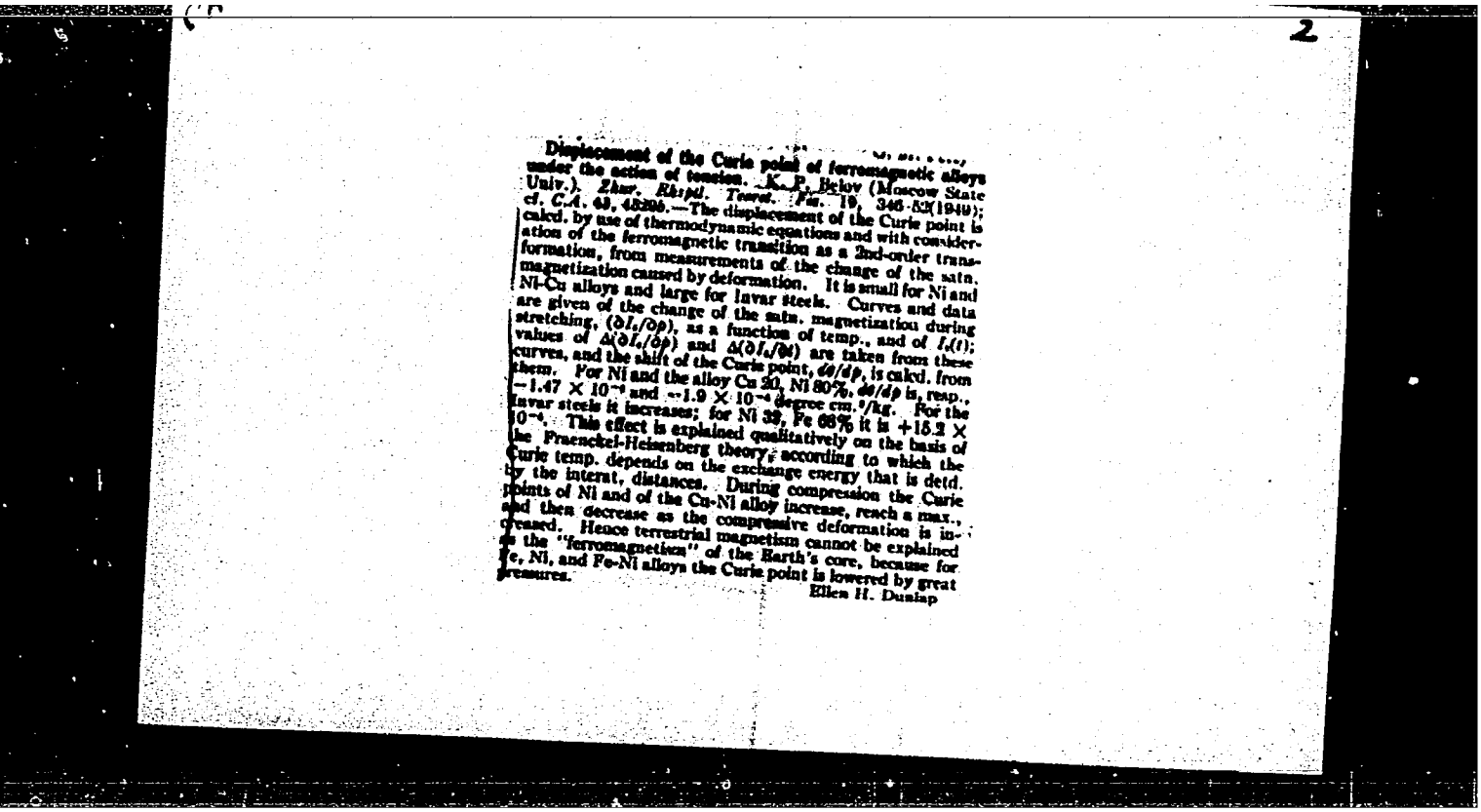
Aug 48

"The Action of Strains on the Magnetization of Ferromagnets in the Paraprocess Region," K. P. Belov, Sci Res Inst of Phys, Moscow State U imeni M. V. Lomonosov, 4 pp

"Dok Ak Nauk SSSR" Vol LXI, No 5

Belov takes issue with Gorlakh's conclusion that elastic deformation has no effect on the value of spontaneous magnetization, but only causes its orientation.

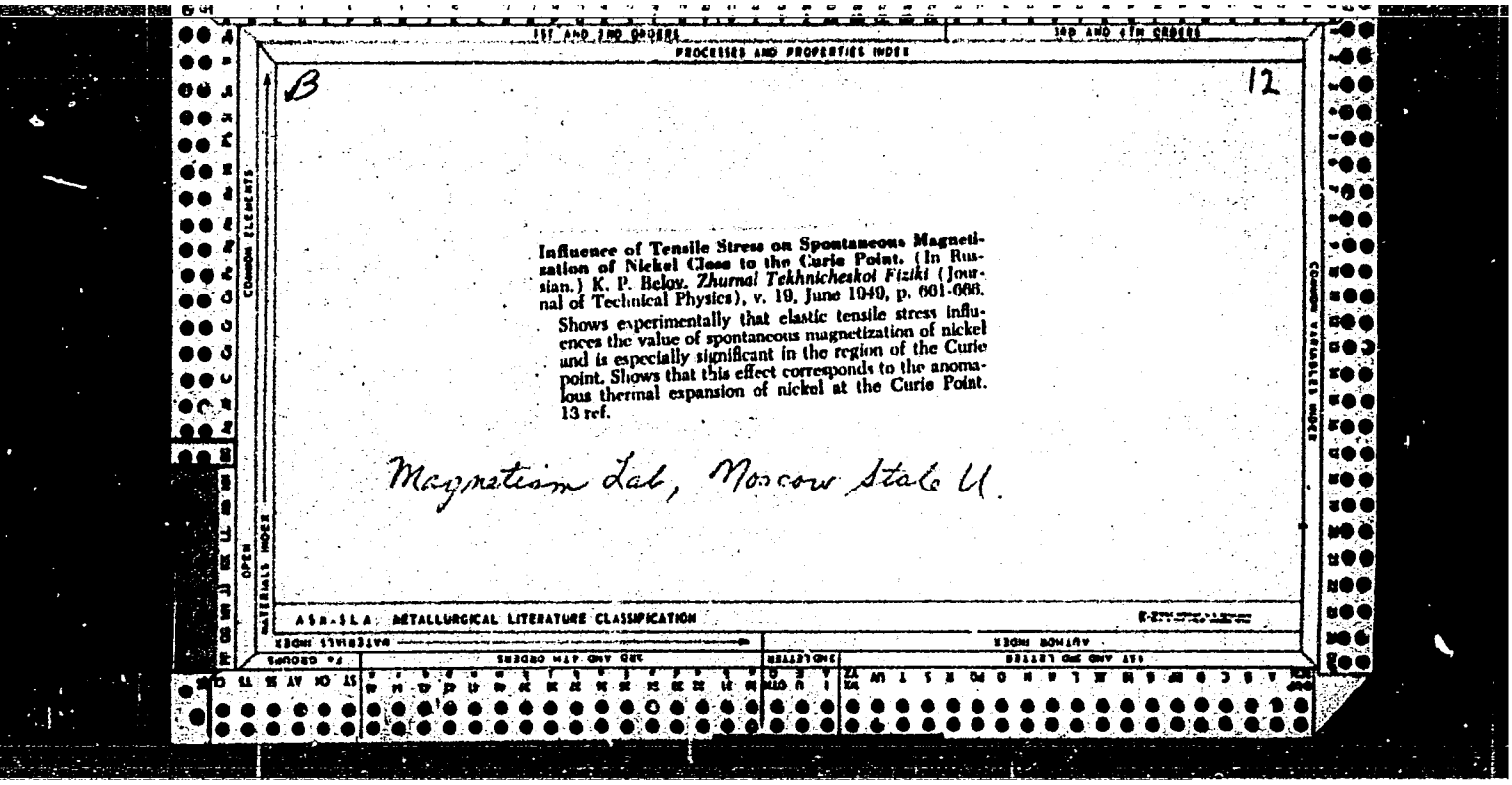
24/49T116



2

Displacement of the Curie point of ferromagnetic alloys under the action of tension. K. P. Belov (Moscow State Univ.). *Zhur. Eksptl. Teoret. Fiz.* 19, 346-52(1949); cf. *C.A.* 43, 4820b.—The displacement of the Curie point is calcd. by use of thermodynamic equations and with consideration of the ferromagnetic transition as a 2nd-order transformation, from measurements of the change of the satn. magnetization caused by deformation. It is small for Ni and Ni-Cu alloys and large for Invar steels. Curves and data are given of the change of the satn. magnetization during stretching, $(\partial I_s/\partial p)$, as a function of temp., and of $I_s(t)$; values of $\Delta(\partial I_s/\partial p)$ and $\Delta(\partial I_s/\partial t)$ are taken from these curves, and the shift of the Curie point, $d\theta/dp$, is calcd. from them. For Ni and the alloy Cu 30, Ni 80%, $d\theta/dp$ is, resp., -1.47×10^{-4} and -1.9×10^{-4} degree cm.^{2}/kg. For the Invar steels it increases; for Ni 35, Fe 65% it is $+15.2 \times 10^{-4}$. This effect is explained qualitatively on the basis of the Frenckel-Heisenberg theory, according to which the Curie temp. depends on the exchange energy that is detd. by the interat. distances. During compression the Curie points of Ni and of the Cu-Ni alloy increase, reach a max., and then decrease as the compressive deformation is increased. Hence terrestrial magnetism cannot be explained as the "ferromagnetism" of the Earth's core, because for Fe, Ni, and Fe-Ni alloys the Curie point is lowered by great pressures.

Ellen H. Dunlap



PROCESSES AND PROPERTIES INDEX

B

12

Influence of Tensile Stress on Spontaneous Magnetization of Nickel Close to the Curie Point. (In Russian.) K. P. Belov. *Zhurnal Tekhnicheskoi Fiziki* (Journal of Technical Physics), v. 19, June 1949, p. 601-606.

Shows experimentally that elastic tensile stress influences the value of spontaneous magnetization of nickel and is especially significant in the region of the Curie point. Shows that this effect corresponds to the anomalous thermal expansion of nickel at the Curie Point. 13 ref.

Magnetism Lab, Moscow State U.

ASM-SLA METALLURGICAL LITERATURE CLASSIFICATION

538.221 : 538.652

The Magnetostriction of Fe/Pt Alloys. - N.S. Akulov, Z.I. Alinade & K.P. Belov. (C. Acad. Sci. U.R.S.S., 21st April 1949, Vol. 65, No1 6, pp. 815-818. In Russian)

370

Curves are shown for various alloys, the highest value of magnetostriction being found for the system 46%Fe/54% Pt. The effect of different treatments on this alloy is studied.

immediate source clipping

BELOV, K. P. Doc Physicomath Sci

Dissertation: "Magnetic-Elastic Effects in Ferromagnetic Materials in the Region of Paraprocess."
18/10/50

Moscow Order of Lenin State U imeni M. V. Lomonosov

SO Vecheryaya Moskva
Sum 71

USSR/Physics - Alloys Jan 50
Magnetostriction

"Magnetostriction of Ferromagnetic Alloys in the Region of the Paraprocess," K. P. Belov, Inst of Phys, Moscow State U, 7 pp

155T57

"Zhur Eksper i Teoret Fiz" Vol XX, No 1

Results of measurements on transverse and longitudinal effects of magnetostriction in alloys of the invar group in magnetic fields higher than "technical" saturation (the region of the paraprocess): the unusually high, in comparison with other alloys, magnetostriction observable in these alloys in

155T57

USSR/Physics - Alloys (Contd) Jan 50

connection with the paraprocess is explained not so much by low position of the Curie point in these alloys as by peculiarities of their structure, which provide very sharp dependence of the volume integral upon the lattice parameter. Submitted 16 Jul 49.

155T57

USSR/Physics - Magnetism 11 Mar 50
Magnetostriction

"Theory of the Even Effect," K. P. Belov, Inst of Phys, Moscow State U imeni Lomonosov

"Dok Ak Nauk SSSR" Vol LXXI, No 2, pp 261-264

Studies dependence of galvanometric effect in Te-Cr alloys and Ni upon magnetic field in Curie region. Considers temperature dependence of galvanometric effect in Ni in the Curie region for various field strengths (H = 2 to 10 oersteds) and magnetostriction of Ni-Fe alloy. Submitted 20 Jan 50 by Acad S. I. Vavilov.

165T80

BELOV, K.P.; GUSEV, A., redaktor, GOLUBKOVA, L.A., tekhnicheskiy redaktor.

[Elastic, thermal and electric phenomena in ferromagnetic metals] Uprugie, teplovye i elektricheskie iavleniia v ferromagnitnykh metallakh. Moskva, Gos. izd-vo tekhniko-teoret. lit-ry, 1951. 254 p. [Microfilm] (MLRA 7:12)
(Ferromagnetism)

USSR/Physics - Paramagnetism Jul 51

"Galvanomagnetic Properties of Iron-Nickel Alloys in the Region of Paraprocesses," K. P. Belov, I. K. Panina, Moscow State U

"Zhur Eksper i Teoret Fiz" Vol XXI, No 7, pp 809-813

Examines galvanomagnetic effect in invar iron-nickel alloys in magnetic flds above technical satn and near Curie pcint (region of paraprocesses) for various temps. Gives results in graphs. Submitted 3 Jul 50.

LC

189T85

USSR/Metals - Alloys, Properties 21 Oct 51

"On the Nature of Elastic Anomalies in Alloys of Invar and Elinvar Types," K. P. Belov, O. N. Agasyan, Sci Res Inst of Phys, Moscow State U imeni M. V. Lomonosov

"Dok Ak Nauk SSSR" Vol LXXX, No 6, pp 881-883

Reviews attempts to explain elastic anomalies by mechanostriction and attributes them to same ferromagnetic volumetric effects which cause anomalies of thermal expansion and density. Discusses temp

217T45

dependence of elasticity modulus and develops formula expressing relation between temp coeff of elasticity modulus and coeff of thermal expansion. Submitted by Acad A. F. Ioffe 17 Aug 51.

217T45

BELOV, K. P.

BELOV, K. P.

PA 241T87

USSR/Physics - Ferromagnetics Jul/Aug 52

"Investigation of Magnetoelastic Phenomena in Ferromagnetics in the Region of the Paraprocess," K. P. Belov, Sci-Res Ins of Phys, Moscow State U

"Iz Ak Nauk, Ser Fiz" Vol 16, No 4, pp 420-431

Discusses magnetoelasticity and magnetostriction effects of special nature due to magnetization above the tech satn pt, during which momenta of domains are fully oriented in the direction of the magnetic field and magnetization increases slightly on account of variation of spin within the domain.

241T87

BELOV, K.P.

Thermodynamics of volumetric and elastic phenomena in ferromagnetic materials near the Curie point. Uch.zap. Mosk. un no.162:15-20 '52. (Ferromagnetism) (MLRA 8:7)

HELOV, K.P.

Temperature dependence of the susceptibility of the para-process of invar alloys. Uch. zap. Mosk. un. no.162:21-32 '52. (MLRA 8:7)

(Nickel- iron alloys--Magnetic properties)

BELOV, K

Erscheinungen In Ferromagnetischen Metallen. Berlin, Technik, 1953.
222 P. Diagrs., Tables.
Translation From The Russian, "Uprchgiye Teplovyi I Elektricheskiye I Elektricheskiye Yavleniya V Ferromagnitnykh Metallakh," Moscow, 1951.
"Literatur": At the end of each chapter.

SO: N/5
613.842
.B4

USSR/Metallurgy - Invar, Anomalous Thermal Expansion — Jan 53

"Magnetostriction and Thermal Expansion of Invar Alloys Near the Curie Point," (1) K. P. Belov, (2) V. V. Shmidt

Zhur Tekh Fiz, Vol 23, No 1, pp 44-49

Contributes to substantiation of hypothesis on connection of anomaly of Invar thermal expansion with ferromagnetism. Using specially designed dilatometer, studies magnetostriction and thermal expansion vs temp on same specimen of alloy with 36%

270T90

Ni, 1% Mo, 63% Fe. Uses data obtained for calculating ferromagnetic portions of coeff of thermal expansion and density of invar.

270T90

BELOV, Konstantin Petrovich, doktor fiziko-matematicheskikh nauk; PLOTNIKOV, K.P., redaktor; AKHLAMOV, S.N., tekhnicheskiy redaktor

[What is magnetism?] Chto takoe magnetizm. Moskva, Gos.izd-vo tekhniko-teoret.lit-ry, 1955. 62 p. (Nauchno-populiarnaia biblioteka, no.81) (MLRA 9:2)

(Magnetism)

BELOV, K.P.; ZAYTSEVA, G.A.

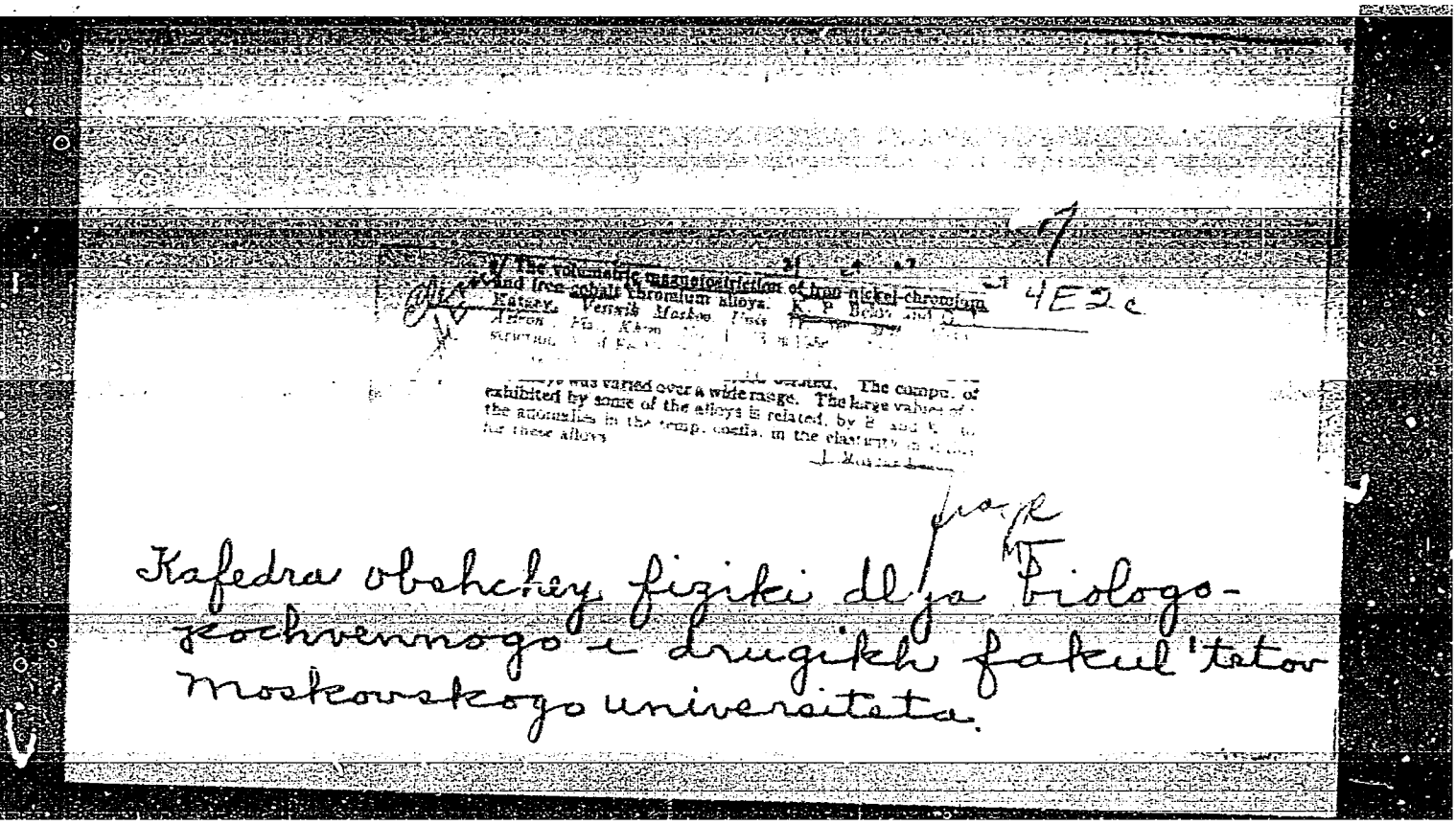
Galvanomagnetic properties of ferromagnetic materials near the Curie point. Fiz. met. i metalloved. 1 no.3:404-409 '55.
(MLRA 9:6)
1.Moskovskiy gosudarstvennyy universitet imeni M.V.Lomonosova.
(Ferromagnetism)

BELOV, K. P., GORYAGA, A. N., and PAKHES, Y. (Moscow)

"Thermodynamic Investigation of Ferromagnetics Substances in the Region of the Curie temperature," a paper submitted at the International Conference on Physics of Magnetic Phenomena, Sverdlovsk, 23-31 May 56.

BELOV, K. P., BOLSHOVA, K. M., and YELKINA, T. A., (Moscow)

"The Study of Magnetization of Ferrites in the Region of the Curie Point," a paper submitted at the International Conference on Physics of Magnetic Phenomena, Sverdlovsk, 23-31 May 56.



4E2c

exhibited by some of the alloys is related, by

Kafedra obshchey fiziki dlya biologo-pochvennogo i drugikh fakul'tetov Moskovskogo universiteta.

Thermodynamic delineation of magnetization of ferromagnetic substances near the Curie point. K. P. Belov and A. N. Goryaga (M.V. Lomonosov State Univ., Moscow). *Fiz. Metal. i Metalloved., Akad. Nauk S.S.S.R. Ural Filial* 2, 3-6(1956).—The thermodynamic theory of phase transitions of the 2nd order developed by Landau and Lifshitz (*Statistical Physics*, 1940, (C.A. 33, 1590[7])) expresses the thermodynamic potential F as a 4-term function, the first 2 terms of which are given as $F = F_0 + a\sigma^2 + b\sigma^4 - \sigma H$ (cf. Ginzburg, *Zhur. Fiz. Khim.* 17, 833(1947)), where σH is the energy of the magnetic pole. At equil. where $\partial F/\partial\sigma = 0$, it becomes $\alpha\sigma + \beta\sigma^3 = H$, where $\alpha = 2a$, and $\beta = 4b$. This is supported by the exptl. values of the sp. magnetization σ of Ni and of Fe-Ni and Cu-30 [illegible] % shows. The exptl. plots of σ^2 vs. H/σ are linear funct[illegible], expressed empirically by $\alpha + \beta\sigma^2 = H/\sigma$ or by $\alpha(\sigma_s + \sigma_i) + \beta(\sigma_s + \sigma_i)^3 = H$ (I), where $\sigma_s + \sigma_i = \sigma$, σ_s is the sp. satn. magnetization, numerically equal to the spontaneous magnetization, and σ_i is the sp. true magnetization (para process). From the linear functions of σ^2 vs. H/σ, at different temps. near the Curie point θ, the values of α (intercept on the H/σ axis) and β (the slopes of the lines) are obtained by extrapolation. The [illegible] of β [illegible] similar to those obtained from the thermodynamic theory, i.e. at $T < \theta$, α is neg.; at $T = \theta$, $\alpha = 0$; at $T > \theta$, α is pos.; β is pos. at all temps. These relative values are also derived from the function of Weiss-Heisenberg despite the fact that this function is only an approximation, since the values of σ_0 (sp. magnetization at 0°K.) obtained by it do not agree with the exptl. values at low temps. The intercept of the extrapolated σ^2 vs. H/σ lines on the σ^2 axis at $H = 0$ (and accordingly $\sigma_i = 0$) give σ_s^2, and thus the values of σ_s are obtained from equation I as $\sigma_s^2 = -\alpha/\beta$. σ_s obtained by I and experimentally by the magnetocaloric method of

1/2

APPROVED FOR RELEASE: 06/06/2000 CIA-RDP86-00513R000204510001-8"

BELOV, K.P., GORYAGA, A.N.

6

Weiss, *et al.* (C.A. 20, 1941) are linear functions of $(\theta - T)$, which is in agreement with the thermodynamic theory. However, the lines obtained for the data of Weiss, *et al.*, lie below those obtained by equation I. A further refinement of the thermodynamic method is illustrated by the curves σ_s *vs.* T. Both methods give curves which are parallel and close to each other up to a point $\alpha = 0$, i.e. near the Curie point. But the curves of σ_s obtained by equation I continue monotonously until they intersect the T axis at $T = \theta$, thus the Curie point is located, whereas the curves obtained from the data of Weiss, *et al.*, break at $\alpha = 0$ and tend to approach the T axis at values far above θ. The magnetocaloric values of σ_s include the "residual" spontaneous magnetization, whereas the latter is not included by the thermodynamic method. The phys. interpretation of this deviation is given by the assumption that the Curie point corresponds to the temp. at which the spin distribution becomes unordered and above which the "residual" spontaneous magnetization becomes vanishingly small.

I. Bencowitz

8

4E2c-1

Thermodynamic method for studying the ferromagnetic transformation of alloys. K. P. Belov and A. N. Goryaga (M. V. Lomonosov State Univ., Moscow). *Fiz. Metal.* [illegible] (1) [illegible] (1955).—The [illegible] substance [illegible] is difficult in the case of [illegible] (Curie [illegible] with the Weiss-Heisenberg [illegible] qual [illegible] present exp. [illegible] authors [illegible] of their [illegible] for estimating this transformation [illegible] measurement. The material tested consisted of pure Ni and 5 Cu-Ni alloys [illegible] [illegible] (θ − T) vs. (σ_s)², the square of spontaneous magnetization [illegible] are shown of (Weiss). The most striking graph shows the absolute linearity of Curie temp. with Cu concn. up to 23.7 at. %, as detd. by the authors, and the same graph further points up to about 32 at. % found in the literature. Also curves are given, which were designed to show the structure sensitivity of magnetic susceptibility and of spontaneous magnetization.

V. H. Gottschalk

BELOV, K.P.

USSR / Magnetism. Ferromagnetism

F-4

Abs Jour : Ref Zhur - Fizika, No 3, 1957, No 6845

Author : Belov, K.P.
Inst : Moscow State University, Moscow
Title : Concerning the Thermodynamic Theory of Magnetoelastic and Magnetostruction Phenomena in Ferromagnetics.

Orig Pub : Fiz. metallov i metallovedeniye, 1956, 2, No 3, 447-453

Abstract : The influence of elastic stresses on spontaneous magnetization and magnetostriction of the para-process near the Curie point is examined from the thermodynamic point of view. Equations are given for the dependence of these effects on the elastic stresses, on the magnetic field, and on the temperature. The theoretical deductions are in agreement with the experimental data.

Card : 1/1

BELOV, KONSTANTIN, PETROVICH

PHASE I BOOK EXPLOITATION 404

Belov, Konstantin Petrovich

Uprugiye, teplovyye i elektricheskiye yavleniya v ferromagnetikakh (Elastic, Thermal and Electric Phenomena in Ferromagnetic Metals) 2d ed., enl. Moscow, Gostekhizdat, 1957. 279 p. (Fiziko-matematicheskaya biblioteka inzhenera) 7,000 copies printed.

Eds.: Alekseyev, D. M. and Denisov, I. I.; Tech. Ed.: Akhlamov, S. N.

PURPOSE: The monograph is intended for specialists engaged in the investigation, research and utilization of magnetic materials. It can also be of use to students of specialized vuzes.

COVERAGE: The monograph represents a systematic account of the latest data on elastic, thermal and electric phenomena in ferromagnetic metals, alloys and ferrites (magnetostriction, elastic stress effect on magnetization, galvano - and thermo magnetic effects, thermal expansion, heat capacity, electric resistance, etc. The author has introduced, wherever possible,

Card 1/8
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new experimental data, in particular, the results of experiments made at the laboratories of Moscow University. He pays special attention to the presentation of experimental results obtained from the study of elastic, electric and change-of-volume phenomena in the ferromagnetic metals and alloys in the third region of the magnetization process (above technical saturation and close to the Curie point). The author studied extensively the little explored phenomena accompanying the third region of the magnetization process, termed here the "paraprocess". The author describes in detail the results of his own investigations, which offer a better understanding of the properties of Invar and Elinvar steel types. In writing the book, the author took care to present the general physical picture of the phenomena, ideas and experimental data in such a way as to make the book accessible to engineers and scientist not specialists in the field of ferromagnetism, as well as to students of universities and higher technical schools studying this field of solid-state physics. The first edition of the book was translated into German in 1953 under the title "Erscheinigungen in Ferromagnetischen Metallen." This second edition contains supplementary information on data published between 1951-1957. There are several references to Soviet personalties in the text. There are 287 references, 181 of which are Soviet (including 2 translations), 58 English, 28 German, 18 French, 1 Czech, 1 Rumanian .

Card 2/8

BELOV, K.P.

137-58-1-1555

Translation from: Referativnyy zhurnal, Metallurgiya, 1958, Nr 1, p 208 (USSR)

AUTHORS: Belov, K. P., Panina, I. K.

TITLE: Effect of the K State on the Temperature Dependence of Spontaneous Magnetization and Magnetostriction (Vliyaniye K-sostoyaniya na temperaturnuyu zavisimost' spontannoy namagnichennosti i magnitostriktsii)

PERIODICAL: Vestn. Mosk. un-ta, ser. matem., mekhan., astron., fiz., khimii, 1957, Nr 1, pp 44-46

ABSTRACT: Measurement of the temperature dependence of spontaneous magnetization σ_s and the magnetostriction constant λ was performed on an invar-type alloy (36% Ni, 6% Mo, 58% Fe), in which ordering does not occur. The purpose of the tests was a study of the low-temperature annealing in alloys in which a K state obtains. After hardening from 950°C and 8-hour tempering at 500°, an increase in electrical resistivity, which was ascribed to the K state, was observed in the alloy. The variation of the $\sigma_s = f(t)$ and $\lambda_s = \varphi(t)$ curves in the 20-200° interval was determined by extrapolation of the curves for the relationship of magnetostriction to the square of magnetization

Card 1/2

Effect of the K State on (cont.)

and by the method employing the thermodynamic coefficient. It is shown that after heat treatment corresponding to that required for the formation of the K state, the alloy has two Curie temperatures (155 and 168°), testifying to the appearance of "atomic segregation", exhibiting the properties of a phase with 155° as its Curie(magnetic transformation) temperature.

V. R.

1. Magnetostriction--Temperature effects 2. Magnetism--Measurement

Card 2/2

AUTHOR: Belov, K. and Paches, Ya.

TITLE: Temperature characteristic of spontaneous magnetisation in alloys in the Curie-point temperature range. (O temperaturnom khode zamoproizvol'noy namagnichennosti v splavakh v oblasti tochki kyuri.)

PERIODICAL: "Fizika Metallov i Metallovedenie," (Physics of Metals and Metallurgy), 1957, Vol. [illegible] No.1 (10), pp. 48-53, (U.S.S.R.)

ABSTRACT: The curves of the temperature dependence of spontaneous magnetisation in the Curie-point range for nickel and some nickel alloys were determined by three differing methods. It was established that the so-called "tails" in the curves of spontaneous magnetisation in the Curie point temperature range are particularly large in these alloys. Their shape and length is strongly dependent on the heat treatment and concentration of the element which is alloyed with the nickel. On the basis of analysis of the experimental material on magnetic and electric phenomena in nickel alloys a more accurate method of determination of the Curie temperature is proposed. To obtain reliable results on the temperature characteristics of the spontaneous magnetisation near the Curie point the Curie point was determined for each specimen by the following three methods: the spontaneous magnetisation I_s was determined from the curves "galvano-magnetic effect -square value of the magnetisation", which were recorded for the specimens under

Temperature characteristic of spontaneous magnetisation in alloys in the Curie-point temperature range. (Cont.)

consideration in the Curie point range; the values of I_s were determined by the method of "lines of equal magnetisation" which is based on the evaluation of the magnetisation isotherms recorded in the Curie temperature range and has been described by Weiss and Forrer (Ann. d. Phys., 1926, 5, 153); I_s was determined by the method of "Thermo-dynamic coefficients" described by Belov and Goryaga (same journal, 1956, Vol.II, No.1, p.3, etc.) which is based on comparing the experimental magnetisation isotherms with the equation of the real magnetisation resulting from the thermo-dynamic theory of ferromagnetic transformation. The curves obtained according to these three methods are compared. The Curie point determined on the basis of the thermo-dynamic coefficients is always above the maximum of the temperature coefficient of the resistance and the negative galvano-magnetic effect; at this temperature the major part of the specimen is in the paramagnetic state and the $I_s(T)$ curve has the character of a tail, which indicates that only small sections of the specimen are in the ferromagnetic state. Therefore, this method of determination of the Curie point is considered the most correct and it is simpler than measuring the temperature dependence of such "non-magnetic" phenomena as the electric resistance, galvano-magnetic effect, the heat

capacity, etc., since in this case it is only necessary to measure magnetic values. For non-uniform materials the average Curie temperature can be determined from the curves of the real magnetisation. The magnetic values were determined according to four different methods for the following materials: Nickel; nickel + 3.1% Si, Ni + 4.9% Si, same after annealing, Ni + 2.5% Mn, Ni + 20% Mn, 38% Ni + 52% Fe. The numerical data for these materials are given in a table, p.52. 5 figures, 1 table. 4 references, 2 of which are Russian.

Moscow State University imeni V.M. Lomonosov. Recd.Mar.21, 1956.

AUTHOR: Belov, K.P. and Panina, I.K.

TITLE: Calculation of the shift in the Curie temperature as a function of the pressure on the basis of magnetostriction data. (Vychislenie velichin smeshcheniya temperatury kyuri ot davleniya iz magnitostriktsionnykh dannykh.)

PERIODICAL: "Fizika Metallov i Metallovedenie" (Physics of Metals and Metallurgy), 1957, Vol. IV, No.1 (10), pp.185-186 (U.S.S.R.)

ABSTRACT: On the basis of the theory of Type II phase transitions an equation was derived in an earlier paper of the author (same journal, 1956, Vol.2, No.3, p.447) for calculating the real magnetisation near the Curie point, taking into consideration elastic stresses acting on the ferro-magnetic:

$$(\alpha + \gamma\Delta p)\,\sigma + \beta\sigma = H$$

where σ - specific magnetisation;
Δp - stress, for instance hydrostatic pressure;
α and β - temperature dependent thermodynamic coefficients;
γ - magnetostriction.

It is shown that by determining γ from the magnetostriction - square of real magnetisation curves measured near the Curie point it is possible to carry out the desired calculations. Calculated data are given for various Ni-Fe, Ni-Fe-Co, Ni-Fe-Mo Ni-Fe-W etc. alloys. 2 graphs, 1 table, 5 references, four of which are Russian.

Moscow State University
imeni M. V. Lomonosov.

Recd. July 28, 1956.

BELOV, K.P.

AUTHORS: Belov, K.P., Goryaga, A.N. 48-8-1/25

TITLE: Effects of Structural Properties of Ferromagnetica on the Temperature Dependence of Spontaneous Magnetization (Vliyaniye strukturnykh osobennostey ferromagnetikov na temperaturnyy khod spontannoy namagnichennosti)

PERIODICAL: Izvestiya AN SSSR Seriya Fizicheskaya, 1957, Vol. 21, Nr 8, pp. 1038 - 1046 (USSR)

ABSTRACT: It is maintained in this paper, that at present no systematic experimental data on the effects produced by structural properties on the temperature dependence of the spontaneous magnetization of alloys in the vicinity of the Curie-point are to be found in publications. This paper furnishes such data with respect to some nickel-alloys, which were obtained according to two methods. 1.) the method by Weiss and Forrer, which consists in the extrapolation of the curves $H(T)$ σ = const of spontaneous magnetization for different intensities of magnetization to the value $H = 0$, and 2.) the method of thermodynamic coefficients, according to the thermodynamic equation $\alpha\sigma + \beta\sigma^3 = H$ (σ denoting the specific magnetization, and α, β thermodynamic co-

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Effects of Structural Properties of Ferromagnetica on the Temperature Dependence of Spontaneous Magnetization

efficients.). Three examples of alloys are considered in the paper: Ni-Cu, Ni_3Mn and Ni-Fe (invar alloy). In the first case (Ni-Cu) the author arrives at the conclusion, that the temperature dependence of spontaneous magnetization, as well as the thermodynamic coefficients α, β are very sensitive to variations of the concentration of the components in the vicinity of the Curie point. A quantitative comparison of the values of the coefficients of such alloys with a varying copper content is only possible after a prolonged annealing (90 hrs). A comparison of the coefficients (ξ) for nickel and nickel-copper alloys showed, that the value of ξ decreases with an increasing copper content in the alloy. According to the theory by Vonsovskiy and Vlasov in the case of Ni-Cu alloys the gradient of the straight line $(\sigma_s/\sigma_0)^2$ (T/Θ) decreases with the decrease of the exchange-interaction (s-d). In the second case of the Ni_3Mn compound the author is lead to the conclusion, that the "tails" of the curves of spontaneous magnetization do not shrink during annealing, but grow in length. Ferromagnetic transformation is weakened here. Therefore a regular arrangement is difficult to obtain. In the third case of the Ni-Fe invar alloy magnetic ano-

Effects of Structural Properties of Ferromagnetica on the Temperature Dependence of Spontaneous Magnetization

malies are mentioned. The temperature dependence of spontaneous magnetization near Curie point is here dependent on thermic history. Experiments have shown in this case that the ferromagnetic transformation of this alloy is extraordinarily weakened with respect to the temperature interval. As a possible source of this phenomenon it is considered, that the ferromagnetism in such alloys is caused by an unstable atomic interaction in the first sphere of coordination, as well as in the subsequent spheres, which gives rise to the weakening of the ferromagnetic transformation. There are 13 figures, 2 tables and 12 references, 8 of which are Slavic.

ASSOCIATION: Dept. of Physics of the Moscow State University imeni M.V. Lomonosov (Fizicheskiy fakultet Moskovskogo gos. universiteta im. M.V. Lomonosova)

AVAILABLE: Library of Congress

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BELOV, K.P.

AUTHORS: Belov, K.P., Bol'shova, K.M., Yelkina, T.A. 48-8-2/25

TITLE: Investigation of Ferrites in the Vicinity of the Curie-Point (Issledovaniye namagnichivaniya ferritov v oblasti tochki Kyuri)

PERIODICAL: Izvestiya AN SSSR, Seriya Fizicheskaya, 1957, Vol. 21, Nr 8, pp. 1047 - 1054 (USSR)

ABSTRACT: The paper under consideration deals with the magnetization processes of some ferrites in order to determine the temperature change of spontaneous magnetization near to the Curie point. It is maintained here, that such data are missing in literature, although they are of great importance, because the mechanism of ferromagnetic phenomena in ferrites are different from ferromagnetic metals. The sections of the paper are headed:

1.) Samples and methods: 7 samples of Mn-Zn ferrites with a varying MnO content (20 ÷ 40 %) and 2 ferrites of Co-Zn alloy were selected. The measuring of the magnetization curves was executed according to the ballistic method. The samples were magnetized in a solenoid with a field strength of 2500 Oe. A ballistic differential winding, consisting of two sections of

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Investigations of Ferrites in the Vicinity of the Curie-Point

4500 spires each on an ebonite body, was mounted on the electric furnace containing the sample. For calibration a one-layer winding of thin wire was prepared, which was wound on a body of the identical form and size as the sample. By introducing this winding instead of the sample calibration was effected. 2.) The curves of actual magnetization of ferrites near the Curie point: Here it is established, that in this case the well-known thermodynamical equation

$$\alpha + \beta\sigma^2 = -\frac{H}{\sigma}$$ is applicable, σ denoting the specific magnetization and α, β thermodynamical coefficients. The conclusion is drawn, that the sequence of the values of the para-processes of ferrites under investigation corresponds to the sequence of ferromagnetic metals. The theoretic relation between the intensity of the paraprocess and the value of the Curie point is stated here as follows: The lower the Curie point, the weaker is the interaction and the higher the effect of the excitation of the external field, implying a higher intensity of the paraprocesses. 3.) The reaction of Mn-Zn ferrites in weak fields near to the Curie point: Here the magnetic anomalies are described, of which allegedly no data are to be found in literature. These data consist of the fact, that the final magnetiza-

Investigations of Ferrites in the Vicinity of the Curie-Point

tion of the above-mentioned Mn-Zn ferrites, starting from low temperatures, first decreases at the approach of the Curie point, starts to grow just before reaching the Curie point, and finally falls off after reaching a certain maximum. The coercive force behaves similarly, which, in some cases, shows a very accentuated rise from the minimum to the maximum. These anomalies can be reproduced also, if the samples are isolated from the influence of air. No anomalies of this kind were found in Co-Zn ferrites. There are 9 figures, 1 table and 7 references, 5 of which are Slavic.

ASSOCIATION: Dept. of Physics of the Moscow State University imeni M.V. Lomonosov
(Fizicheskiy fakultet Moskovskogo gos. universiteta im. M.V. Lomonosova)

AVAILABLE: Library of Congress

BELOV, K.P.

AUTHORS Belov, K.P., Ped'ko, A.V.

TITLE On the Galvanomagnetic Properties of Ferromagnetica Near Absolute Zero. (O galvanomagnitnykh svoystvakh ferromagnetikov vblizi absolyutnogo nulya temperatury). (Letter to the Editor)

56-3-50/59

PERIODICAL Zhurnal Eksperim.i Teoret.Fiziki,1957,Vol 33,Nr 3,pp 815-817(USSR)

ABSTRACT The observation made by Smith that,in a 42% Ni and a 58% Fe alloy, Q does not only not diminish at the temperature of liquid nitrogen and liquid hydrogen,but even increases,was confirmed by a more accurate determination of Q at the temperature of liquid helium.Besides, the same was observed in the case of other ferromagnetic alloys.

The following measurement values for Q were obtained for not annealed alloys at the temperature of liquid helium:

alloy	Q. 10^8
42 % Ni, 58 % Fe	31,6
50 % Ni, 50 % Fe	15,6
20 % Cu, 80 % Ni	25,5
25 % Cu, 75 % Ni	11,6
23 % Mn, 77 % Ni	23,6

There are 2 figures.

~~Card 1/2~~ Moscow State U.

56-6-35/47

AUTHORS: Belov, K. P., Talalayeva, Ye. V.

TITLE: The Galvanometric Properties of Manganese Ferrite (Gal'vanomagnitnyye svoystva ferrita margantsa)

PERIODICAL: Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, 1957, Vol. 33, Nr 6 (12), pp, 1517 - 1519 (USSR)

ABSTRACT: The authors carried out measurements of the temperature dependence of the galvanometric effect in a ferrite with 50 % (Mol-%) MnO and 50 % Fe_2O_3. Such a ferrite did not have too great a resistance and on it it was possible to measure the effect in the case of direct current in the temperature interval of room temperature up to 350°. The ferrite was produced by means of the usual "ceramic" technology from chemically pure oxides. As samples rods of 52 mm length and 25 mm^2 cross section were used. On the front surfaces of the samples the contacts for current feed were fitted by burning in a silver paste. The sample was located in a furnace with bifilar winding; the furnace itself was in a magnetizing solenoid. The galvanometric effect was measured by the method of the bridge not in equilibrium. At each given temperature the electric resistance, the galvanometric effect $\Delta R/R$, and the specific magnetization

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BELOV, K. P.

SUBJECT USSR / PHYSICS CARD 1 / 2 PA - 1864
AUTHOR BELOV,K.P., PANINA,I.K.
TITLE The Determination of the Spontaneous Deformation of the Lattice on the occasion of Ferromagnetic Transformation.
PERIODICAL Dokl.Akad.Nauk 111, fasc.5, 985-987 (1957)
Issued: 1 / 1957

The present work describes a method for the determination of the spontaneous deformation of the lattices of ferromagnetica based upon measuring the temperature dependence of magnetostriction, and furnishes results for several alloys. According to K.P.BELOV, F.M.M. (= ?) 2, fasc.3, (1956) the thermodynamic potential of the ferromagneticum near CURIE temperature can be represented in the form $\Phi = \Phi_0 + a\sigma^2 + b\sigma^4 + cp + dp^2 + e\sigma^2 p - H\sigma$. ($\sigma$ - specific magnetization, p - mechanical voltage, $H\sigma$ - energy of the magnetic field; a,b,c,d,e - thermodynamic coefficients). Here d and e are proportional to the elasticity modulus and the magnetostriction constant respectively. For the relative modification of the volume $\omega = c + 2dp + e\sigma^2$ is found. For $p = 0$ it is true that $\omega = e\sigma^2$ if the addititive constant is omitted. For a linear deformation it holds that $\lambda = e(\sigma_s + \sigma_i)^2/3$. Here σ_s denotes spontaneous magnetization and σ_i - true magnetization and it holds that $\sigma = \sigma_s + \sigma_i$. Thus, the aforementioned equation can be derived also by rigorous thermodynamic equations. This dependence is also graphically represented. In the case of a lacking spontaneous

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magnetization, also spontaneous deformation (at H = 0)will be lacking. On the occasion of the occurrence of spontaneous magnetization (e.g. if temperature is cooled to less than Curie temperature), also spontaneous deformation of the lattice occurs, which amounts to $\lambda_s = e\sigma_s^2/3$. If a magnetic field is applied, true magnetization σ_i will occur together with a magnetostriction λ_i, which occurs in addition to the spontaneous deformation λ_s of the lattice. With the help of an attached diagram it is possible, after measuring the magnetostriction λ_i (as a function of a square of magnetization) to determine not only spontaneous magnetization but also the spontaneous deformation of the lattice of the ferromagnetioum caused by the exchange forces. A diagram shows the curves (magnetostriction - square of magnetization) for the alloy 31% Ni, 5% Co, 64% Fe, which were recorded at different temperatures and field strengths which were above technical saturation. According to this diagram λ_i depends linearly on the square of true magnetization. Also the temperature dependence of λ_s near CURIE point can be determined on the basis of thermodynamic considerations. $\lambda_s = (1/3)(\alpha'_\theta e/\beta)(\theta - T)$ is found, i.e. in the vicinity of CURIE temperature λ_s must depend linearly on T. In the case of experiments carried out with alloys this linear dependence does not always apply, which is due to inhomogeneities of the concentration of the alloy. If the spontaneous deformation of the lattice is known, the ferromagnetic anomaly of thermal expansion in the ferromagnetica can be determined.

INSTITUTION: Moscow State University.

24(3)

AUTHORS: Belov, K.P. and Kadomtseva, A.M.

TITLE: On the Influence of One-Sided Elastic Deformations on the Curie Point of Ferromagnetics (O vliyanii odnostoronnikh uprugikh deformatsiy na tochku Kyuri ferromagnetikov)

SOV/55-58-2-17/35

PERIODICAL: Vestnik Moskovskogo Universiteta, Seriya matematiki, mekhaniki, astronomii, fiziki, khimii, 1958, Nr 2, pp 133-136 (USSR)

ABSTRACT: An experimental investigation of the influence of unidirectional elastic tensions on the Curie point led to the following results: The displacement of the Curie point under unidirectional tension is three times smaller than under universal tension and is essentially caused by the change in volume which follows the tension. A torsion does not displace the Curie point.
There are 3 figures, and 6 references, 4 of which are Soviet, and 2 American.

ASSOCIATION: Kafedra obshchey fiziki dlya biologo-pochvennogo i dr. f-tov (Chair of General Physics of the Faculty of Soil Biology and other Faculties) [Moscow Univ.]

SUBMITTED: June 26, 1957

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24(3)

AUTHORS: Belov,K.P., and Ped'ko, A.V.

TITLE: The Influence of the Paraprocess on the Galvanomagnetic Effect of Ferromagnetica at Low Temperatures (Vliyaniye paroprotsessa na gal'vanomagnitnyy effekt ferromagnetikov pri nizkikh temperaturakh)

SOV/155-58-2-45/47

PERIODICAL: Nauchnyye doklady vysshey shkoly. Fiziko-matematicheskiye nauki, 1958, Nr 2, pp 214-219 (USSR)

ABSTRACT: This is a report on experimental measurements of the galvanomagnetic effect in ferromagnetic combinations for boiling temperatures of nitrogen, hydrogen, and helium. The measurements showed the insufficiency of the formula proposed by Smit [Ref 2]. For several alloys a residual galvanometric effect could be measured (residual effect). Two possible interpretations for the appearance of the residual effect are proposed. The authors thank Professor A.I.Shal'nikov for valuable suggestions.
There are 2 tables, 5 figures, and 6 references, 4 of which are Soviet, and 2 American.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet imeni M.V.Lomonosova (Moscow State University imeni M.V.Lomonosov)

SUBMITTED: January 13, 1958

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24(3)

AUTHORS: Belov,K.P., and Talalayeva, Ye.V.

SOV/155-58-2-46/47

TITLE: Temperature Dependence of the Galvanomagnetic Effect and the Electric Resistance of Manganese Ferrite in Poly- and Monocrystalline States (Temperaturnaya zavisimost' gal'vanomagnitnogo effekta i elektrosoprotivleniya v ferrite margantsa v poli- i monokristallicheskom sostoyaniyakh)

PERIODICAL: Nauchnyye doklady vysshey shkoly. Fiziko-matematicheskiye nauki, 1958, Nr 2, pp 220-227 (USSR)

ABSTRACT: The comparison of experimentally measured electric resistances of poly- and monocrystalline manganese ferrites shows that they have the same order of magnitude (S_{polycr} = 200 ohm/cm, S_{monocr}=800 ohm/cm) Herefrom it is concluded that the electric resistance of the manganese ferrite is determined by the ferrite itself (not by the boundary layers between the grains). In the neighborhood of the Curie-point the galvanomagnetic effect is influenced strongly by the paraprocess; in the neighborhood of the Curie-point the curve $\lg \rho \left(\frac{1}{T} \right)$ has a complicated crack with a flat point. The authors measured a positive component of the galvanomagnetic longitudinal effect unusual for ferrites. The results are compared with those

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Temperature Dependence of the Galvanomagnetic Effect and the Electric Resistance of Manganese Ferrite in Poly- and Monocrystalline States

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of Komar and Klyushin [Ref 2], Irkin and Turov [Ref 10] and others. The authors thank A.A.Popova (Institute of Crystallography) for giving a crystal.
There are 9 figures, and 11 references, 10 of which are Soviet, and 1 American.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet imeni M.V.Lomonosova (Moscow State University imeni M.V.Lomonosov)

SUBMITTED: January 15, 1958

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24(3)

Author: D'yakov, G.P., Candidate of Physical-Mathematical Sciences SOV/55-58-2-34/35

TITLE: Survey of Papers Read by Scientists of Moscow University at the All-Union Congress on the Physics of Magnetic Materials (Obzor dokladov uchenykh Moskovskogo universiteta na vsesoyuznom soveshchanii po fizike magnitnykh materialov)

PERIODICAL: Vestnik Moskovskogo Universiteta. Seriya matematiki, mekhaniki, astronomii, fiziki, khimii, 1958, Nr 2, pp 247-250 (USSR)

ABSTRACT: From December 6 - 11, 1957 there took place the fourth Union Congress on physics of magnetic materials in Leningrad. (The first two meetings took place 1946 and 1951 in Sverdlovsk, the third meeting 1956 in Moscow). The congress was organized by a Academy of Sciences of the USSR, Department of Physical-Mathematical Sciences, Scientific Council on Fundamental Problems of Magnetism, Institute for Semiconductors of the Academy of Sciences, USSR and Committee for Magnetism. There were more than 300 participators, 59 lectures were given, among them the following lectures of the representatives of the Moscow State University:

1. Professor R.V. Telesnin, Ye.F. Kuritsyna, Lecturer "On the Velocity of Magnetic Reversal of the Ferromagnetics".
2. Professor R.V. Telesnin, Ye.V. Karchagina, Assistant "On Magnetic Viscosity of Ferrites".
3. Professor R.V. Telesnin, I.G. Shishkov, Aspirant "Effect of Magnetic Viscosity on the Frequency Characteristics of Ferrites".
4. N.V. Degtyar, Lecturer "Variations of Structure and Antiferromagnetic Properties of Ni_3Fe".
5. N.A. Grabovskiy, Lecturer, S.Yu. Brodskaya, Junior Scientific Assistant "Magnetic Properties of Anisotropic Stones".
6. G.P. D'yakov, Lecturer "Magnetostriction Properties of Binary Alloys".
7. Professor Ye.I. Kondorskiy, L.V. Sobolev, Assistant "Electric Properties of Ni-Zn-Ferrites".
8. N.Z. Miryasov, Senior Scientific Assistant, A.P. Parsanov, Aspirant "Magnetic Properties and Structure of Manganese - Boron - Alloys".
9. N.A. Smol'kov, Senior Scientific Assistant, B.F. Belov "Some Properties of Ferrites".
10. N.A. Smol'kov, Senior Scientific Assistant, Yu.P. Simanov, Lecturer "Properties of $NiFe_2O_4 - MgFe_2O_4$".
11. N.A. Smol'kov and Ye.I. Fomenko, Engineer "Properties of Ferrites in the High-Frequency Range".
12. Professor K.P. Belov, K.M. Bol'shova, Lecturer, T.A. Yelkina, Lecturer, and M.A. Zaytseva, Junior Scientific Assistant "Ferrites With Compensation Point".
13. K.P. Belov, Ye.P. Svirina, Assistant "Electric and Galvanomagnetic Properties of the Manganese Ferrites".
14. V.A. Timofeyeva, Junior Scientific Assistant, A.V. Zalesskiy "Production of Monocrystals of Ferrites".
15. Professor K.P. Belov, A.V. Ped'ko, Junior Scientific Assistant "On Galvanomagnetic Properties of Ferromagnetic Alloys Near the Absolute Zero of Temperature".

The participators of the meeting visited a laboratory of the Institute of Semiconductors of the Academy of Sciences of the USSR (Professor S.A. Smolenskiy).
The meeting was concluded by Professor S.V. Vonsovskiy, Corresponding Member, Academy of Sciences, USSR with the indication to the following Union Congress planned for 1958.
1. Magnetic Resonance and Galvanomagnetic Effects in Kazan',
2. Ferromagnetic Semiconductors (Ferrites) - in Minsk.
3. Block-Surface Structure of the Ferromagnetics and Barkhausen Effects - in Krasnoyarsk.

AUTHORS: Belov, K.P. and Zalesskiy, A.V. 70-3-3-33/36

TITLE: The Thermal Expansion and Magnetostriction of Pyrrhotite (Teplovoye rasshireniye i magnitostriktsiya pirrotina)

PERIODICAL: Kristallografiya, 1958, Vol 3, Nr 3, pp 388 - 390 (USSR).

ABSTRACT: Measurements of the thermal expansion of pyrrhotite (of composition about Fe_7S_8) were made by a method already described (Zh.Tekh.Fiz., 1953, Vol 23, p 1 and PTE, 1958, Vol 4). Simultaneously, as a control, the magnetostriction was measured by a ponderometric method. Curves are reproduced. Four variables were measured against temperature-specific magnetisation s in a field of 4760 Oe, magnetostriction λ in a field of 1880 Oe, relative extension dL/L and coefficient of linear expansion α. The curve of the temperature dependence of λ, $\lambda(T)$, is very similar to that of s(T); the magnetostriction is positive and small. In the region of the Curie point in the $\lambda(T)$ curve the characteristic maximum or minimum corresponding to the volume magnetostriction paraprocess is absent. The magnetostriction paraprocess is also not apparent in the curve of $\lambda(H)$ as the field of 2000 Oe is still insufficient. Hence it is

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The Thermal Expansion and Magnetostriction of Pyrrhotite

impossible to estimate the sign and magnitude of the ferromagnetic anomaly in the thermal expansion at the Curie point, ϑ_C. The maximum of the magnetostriction, at the corresponding point ϑ_H = 220 °C, can be observable or not observable, depending on the rates of heating and cooling. In the dL/L there is a sharp jump and in the $\alpha(T)$ curve a sharp maximum at 320 °C. This temperature corresponds to ϑ_V and ϑ_C. $\alpha(T)$ shows no anomaly in the 330-340 °C region. It is concluded that the energy of the disordering of the vacancies is much greater than the energy of spin disordering. Thence all anomalies in the curves $\alpha(T)$ and $\lambda(T)$ and in the magnetisation/temperature curve are due to the energy of disordering the vacancies. Because of the small energy of the spin disordering the latter cannot substantially influence the ordering of the vacancies and there is no mutual influence between the processes of the ordering of spins and vacancies as Lotgering believed (Philips Res. Rep., Vol 11, pp 190-249, 1956). There are 2 figures and 5 references, 2 of which are Soviet, 2 English and 1 French.

ASSOCIATION: Institut kristallografii AN SSSR (Institute of Crystallography, Ac.Sc.USSR)

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SUBMITTED: October 1, 1957.

SOV/70-3-6-13/25

AUTHORS: Belov, K.P., Popova, A.A. and Talalayeva, Ye.V.

TITLE: The Electrical and Galvanomagnetic Properties of Single Crystals of Manganese Ferrite (Elektricheskiye i gal'vanomagnitnyye svoystva monokristallov ferrita margantsa)

PERIODICAL: Kristallografiya, 1958, Vol 3, Nr 6, pp 733-9 (USSR)

ABSTRACT: The temperature dependence of the electrical resistance and the longitudinal galvanomagnetic effect in single crystals of manganese ferrite have been measured. The temperature dependence of the resistance is complicated. Near the Curie point on the lines log r (1/T) breaks are observed which have a step form. It is supposed that these steps arise because at the Curie point crystals of manganese ferrite transform to a degenerate electron state. It is established that the dependence of the longitudinal galvanomagnetic effect on temperature, field and magnetisation is analogous to the dependence observed in metal ferromagnetics. The crystals of $MnFe_2O_4$ used were made by the Verneil process and X-ray and chemical analysis were used to establish the orientation and texture of the specimens which were rods of about 0.2 cm^2 cross-section and 1 cm length. The specific

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The Electrical and Galvanomagnetic Properties of Single Crystals of Manganese Ferrite

resistances r were of the same order as that of the polycrystalline material (1 kΩ.cm). The conductivity is associated with the occurrence of ions in two valency states in alternation in certain directions. The much smaller conductivity observed here than in the case of magnetite is a consequence of the presence of Mn^{+2}, Mn^{+3} and Mn^{+4} ions in the same set of equivalent positions and the absence of Fe^{+3} ions . A graph of the conductivity against temperature is given. Log r against T^{-1} is roughly a straight line but is broken into regions. Each can be described by $r = A \exp dE/kT$ where dE has a different value for each of six sections, namely 0.30, 0.26, 0.20, 0.32, 0.50 and 0.32 eV . The region near the Curie point (near $10^3/T = 1.8$) was studied more closely. It is thought that on the transition from the paramagnetic state to the ferromagnetic the semiconductor passes through a state of electronic degeneracy (as in a metal) and then becomes a semi-conductor again. The slope of the line log r(1/T) should be less in the ferromagnetic state than in the paramagnetic.

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The Electrical and Galvanomagnetic Properties of Single Crystals of Manganese Ferrite

As in the case of most ferromagnetics, the longitudinal galvanomagnetic effect in the region of technical magnetisation has a positive sign. With increasing temperature the sign changes to negative at lower and lower temperatures until at 270 °C the sign is always negative. The effect is also plotted out as a function of the square of the specific magnetisation.
There are 10 figures, 1 table and 6 references, 4 of which are Soviet, 1 French and 1 English.

ASSOCIATION: Institut kristallografii AN SSSR (Institute of Crystallography of the Ac.Sc.USSR) and Moskovskiy gosudarstvennyy universitet im. M.V. Lomonosova (University im. M. V. Lomonosov)

SUBMITTED: July 12, 1958

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SOV/126-6-4-7/34

AUTHORS: Belov, K.P.,
Svirina, Ye.P.,
Belous, Yu.V.

TITLE: Hall Effect in Alloys in the Region of Ferromagnetic Transformation (Effekt Kholla v splavakh v oblasti ferromagnitnogo prevrashcheniya)

PERIODICAL: Fizika Metallov i Metallovedeniye, 1958, Vol6, Nr 4, pp. 621-627 (USSR)

ABSTRACT: The temperature characteristic of the Hall constant has a complicated shape, particularly in the neighbourhood of the Curie point. Usually, the Hall constant at any temperature is determined from the inclination angle of the Hall emf - magnetisation curves. However, the characteristic of these curves changes considerably with the temperature. On approaching the Curie point the role of the processes of displacement and rotation decreases, whilst the role of the real magnetisation (the para-process) becomes paramount. Thus, from the Hall emf - magnetisation curves some "mixed" Hall constant is determined which is caused by the

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Hall Effect in Alloys in the Region of Ferromagnetic Transformation

orientations of the spontaneous magnetisation, which are due to the magnetic forces of the lattice and they are also due to changes in this magnitude caused by the exchange forces. The necessity of determining two separate Hall constants corresponding to the processes of orientation of the magnetic moments of the domains and of the para-process has been pointed out for the first time by Volkov (Ref.7). The authors of this paper have attempted to dispense with the usually applied method of calculation of the Hall constant in ferromagnetics from measured data. Since the fundamental characteristic of a ferromagnetic is its spontaneous magnetisation I_s, an attempt has been made to separate from the experimental data the "spontaneous" Hall effect and to study the variation of this effect with the temperature. This method of studying the temperature dependence of the Hall effect excludes the influence of magnetisation processes brought about by an external field. Investigation of the temperature

Hall Effect in Alloys in the Region of Ferromagnetic Transformation

dependence of the "spontaneous" Hall effect is also of interest from the point of view of verifying conclusions based on quantum mechanics theories of the Hall effect in ferromagnetics (Ref.8) in which this effect is considered as being a function of the spontaneous magnetisation. The authors of this paper investigated alloys with a high paraprocess (invar steels), since in such steels it is easier to separate out the "spontaneous" Hall effect than in other ferromagnetics. Furthermore, all the measurements were carried out in the region of ferromagnetic transformation (near the Curie point) where the processes of technical magnetisation are small, which also makes the determination of the spontaneous Hall effect easier. The investigations were carried out on specimens of the following compositions:
56.0% Co; 10.0% Cr; rest Fe.
36.0% Ni; 6.0% Co; rest Fe.
31.5% Ni; 5.7% Cr; rest Fe.

Hall Effect in Alloys in the Region of Ferromagnetic Transformation

After manufacture, the 6 x 12 x 150 mm specimens were subjected to homogenisation annealing in vacuum at 1000°C for 15 hours with subsequent slow cooling. The magnetisation was determined by a ballistic method. The Hall emf was measured in accordance with a method described by Kikoin (Ref.3) and Pugh (Ref.9) using a photo-electro-optic amplifier as described by Kozyrev (Ref.10). For each specimen the magnetisation and the Hall emf as a function of the field at a given temperature were measured simultaneously. The temperature was varied by means of a furnace with a bifiliar heating wire placed inside the solenoid which generated the uniform magnetic field along the specimen. During the measurements the temperature was maintained constant with an accuracy of ± 0.1°C. The obtained results are graphed in Fig.1-8. It was found that in the neighbourhood of the Curie point the Hall constant

SOV/126-6-4-7/34

Hall Effect in Alloys in the Region of Ferromagnetic Transformation

shows a linear dependence on the square value of the spontaneous magnetisation. There are 8 figures and 11 references of which 6 are Soviet and 5 English.

ASSOCIATION: Moskovskiy Gosudarstvennyy Universitet Imeni M.V.Lomonosova (Moscow State University imeni M.V.Lomonosov)

SUBMITTED: 1st April 1957.

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AUTHORS: ~~Belov, K. P.,~~ Bol'shova, K. M., Yelkina, T. A., Zaytseva, M. A. SOV/48-22-10-23/23

TITLE: On Magnetic Properties of Ferrites Exhibiting a Compensation Point (O magnitnykh svoystvakh ferritov s tochkoy kompensatsii)

PERIODICAL: Izvestiya Akademii nauk SSSR. Seriya fizicheskaya, 1958, Vol 22, Nr 10, pp 1282 - 1292 (USSR)

ABSTRACT: In the present paper the authors performed exact measurements of the magnetic properties of mixed lithium chromite ferrites (which were annealed and hardened) in the case of different annealing after hardening. For the investigation a system of ferromagnetic lithium spinels that contained chromium of the common formula

$$Li_2O \cdot (5 - 2a)\, Fe_2O_3 \cdot 2a\, Cr_2O_3 \quad (\text{for } a = 1{,}25;\ 1{,}5;\ 1{,}6;\ 1{,}7)$$

was synthetized. The following magnetic characteristics were investigated: 1) Temperature dependence of the spontaneous magnetization of $\sigma_s(T)$; 2) magnetic moments of the atoms (the measurements were carried out by A. V. Ped'ko); 3) temperature dependence of the residual magnetization of

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the limiting cycle in the temperature range of from -30° to about 10 to 20° above the compensation point (by the astatic magnetometer); 4) temperature dependence of the paramagnetic sensitivity (according to the ponderomotive method). The measuring results showed that the ferromagnetic spinels Li FeCr in a certain range of solution exhibit an anomalous shape of the curve $\sigma_s(T)$ with a compensation point. This has been predicted by Neel. In contrast to the theory it was found that the compensation never was perfect. The phenomenon of an imperfect compensation may be explained by the heterogeneity of the samples. An other considerably greater difference is that the value of the absolute saturation computed (according to Neel) from the distribution of the cations does not agree at all with data found experimentally (Table 2, column 3 and 5). The modification of Neel's theory suggested by Yafet and Kittel (Ref 8) is capable of explaining this discrepancy qualitatively. The explanation is as follows: As the measured value of the magnetic value in these ferrites is lower than the value computed according to Neel's theory and $M_B > M_A$, in this case the negative exchange

interaction within the sublattice B compared with the interaction between the sublattices A and B must not be neglected. The measurements showed that the value of the absolute saturation in the system LiFeCr-ferrites becomes higher in the case of hardening. In technical publications there are data on the influence of hardening upon σ_o of various simple and composed ferrites (Refs 10 and 11) and theories (Refs 12 - 14) explaining the results of the papers (Refs 10 and 11). According to this σ_o depends on the distribution of the cations on A and B. This distribution, however, depends on the temperature. In the present case the problem became more complicated as apart from the cation distribution also the variation of the angles between the magnetic moments in sublattices was possible. The possible influence of these two factors excludes a comparison of the experimental values found of saturation in hardening with respective theories. The question of the influence of these factors probably might be answered by means of radiographic and especially neutronographic investigations. The authors express their gratitude to K. G. Khomyakov and T. I. Bulgakova

On Magnetic Properties of Ferrites Exhibiting a Compensation Point

SOV/48-22-10-23/23

for valuable suggestions. There are 10 figures, 3 tables, and 14 references, 4 of which are Soviet.

ASSOCIATION: Fizicheskiy fakul'tet Moskovskogo gos.universiteta imeni M. V. Lomonosova (Dept. of Physics at the Moscow State University imeni M. V. Lomonosov)

Card 4/4

USCOMM-DC-60,966

AUTHOR: Belov, K. P.

SOV/53-65-2-9/14

TITLE: Ferromagnetic and Antiferromagnetic Materials Near Curie Point (Ferromagnetiki i antiferromagnetiki vblizi tochki Kyuri)

PERIODICAL: Uspekhi fizicheskikh nauk, 1958, Vol. 65, Nr 2, pp. 207-256 (USSR)

ABSTRACT: Recently much experimental material has accumulated with respect to various physical phenomena in metals, alloys, ferrites, sulfides as well as ferromagnetic and antiferromagnetic materials. It was the aim of the present paper to sort out and to arrange this material systematically. In contrast to other papers, the author here does not employ the method developed by Weiss (Veyss), but the thermodynamical method developed by Soviet authors for the description of phenomena within range of the Curie point. The last survey of this sort is by Gerlach (Gerlakh), 1939 (Ref 5). The thermodynamical theory was worked out by Vonsovskiy and Ginzburg (Refs 3,4) on the basis of the theory of phase transitions (Landau, Ref 2).
The author first deals with the theory of the magnetization curve within the range of the Curie point as well as with the temperature dependence of the thermodynamical coefficient for various

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alloys and the paraprocess in weak fields; numerous experimental results are described in form of diagrams and tables. The course taken by temperature in spontaneous magnetization and the determination of Curie temperature is discussed; for nickel and various Ni-alloys (+ Si, + Mn, + Fe) a table shows the Curie temperatures determined by various methods (method of the maximum of the negative galvanometric effect, method of the maximum resistance temperature coefficient, method of the thermodynamical coefficient, and method of initial permeability). These methods are discussed and described on the basis of experimental material. The influence exercised by a structural change in alloys on the course taken by temperature in the case of spontaneous magnetization and the influence exercised by elastic tensions on magnetization in the course of the paraprocess are dealt with by the following chapters. The author then discusses the phenomenon of magnetostriction and its dependence on H for various alloys (Ni-Co, Ni-Fe), the spontaneous deformation of the lattice in ferromagnetic transformation, and the shifting of Curie temperature under the influence of elastic tensions in ferromagnetic materials. The magnetocaloric

and the galvanomagnetic effect within the range of the Curie temperature are then dealt with; numerous experimental results obtained for various alloys are shown in form of diagrams. The second part of this survey deals with antiferromagnetic materials; this part comprises the following chapters: 1.) The temperature dependence of susceptibility and "nonmagnetic" properties. 2.) Neutronogram investigations (of MnO, MnF_2, FeF_2, CoF_2, NiF_2). 3.) Resonance absorption. 4.) The present stage of the theory of antiferromagnetic transformation according to Landau (Ref 40). 5.) Magnetic transitions in non-compensated antiferromagnetic materials. 6.) The investigation of the temperature dependence of magnetized ferrites with compensation points (this chapter is dealt with in detail, the anomalous temperature curves of numerous ferrites are represented by 8 diagrams). 7.) The electrical properties within range of the Curie point (Fig 41) clearly show the temperature dependence of the galvanomagnetic effect of manganese ferrites for various different

Card 3/4 H - the family of curves $\frac{\Delta R}{R}(T)$ according to reference 81.

8.) The nature of the weak "ferromagnetism" in matter of the hematite type, and, finally 9.) The investigation of the magnetic transformation in pyrrotin (an Fe-S-compound).
All chapters contain a wealth of experimental material and references, to enumerate which would be beyond the scope of a mere abstract. There are 48 figures, 6 tables, and 94 references, 44 of which are Soviet.

1. Antiferromagnetism 2. Ferromagnetic materials--Analysis
3. Ferromagnetic materials--Test results 4. Thermodynamics

AUTHORS: Belov, K. P., Zaytseva, M. A. SOV/53-66-1-8/11

TITLE: New Magnetic Materials - Ferrite-Garnets (Novyye magnitnyye materialy - ferrity-granaty)

PERIODICAL: Uspekhi fizicheskikh nauk, 1958, Vol. 66, Nr 1, pp. 141 - 144 (USSR)

ABSTRACT: The authors in extracts give the contents of a number of foreign papers (mainly from the USA and from France) dealing with ferrites of the formula

$3\ Me_2O_3 \cdot 5\ Fe_2O_3$ (or $Me_3Fe_2Fe_3O_{12}$).

There are 4 figures, 1 table, and 11 references.

1. Magnetic materials 2. Ferrites--Magnetic properties
3. Garnets--Magnetic properties

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PHASE I BOOK EXPLOITATION SOV/3686

Belov, Konstantin Petrovich

Magnitnyye prevrashcheniya (Magnetic Transformation) Moscow, Fizmatgiz, 1959. 259 p. 7,000 copies printed.

Ed.: A. L. Chernyak; Tech. Ed.: Ye. A. Yermakova.

PURPOSE: This book is intended for scientific workers, engineers, and aspirants investigating magnetic phenomena and magnetic materials.

COVERAGE: This study of magnetic transformations contains experimental data on magnetic phenomena (ferrimagnetism, antiferromagnetism, ferromagnetic resonance) in the region of the Curie point. The data obtained by the author and his coworkers were interpreted by a thermodynamic method developed by Soviet scientists, as well as by new model theories such as the s - d electron exchange model of S. V. Vonsovskiy. The thermodynamic method was used in analyzing the temperature dependence of spontaneous magnetization in the neighborhood of the Curie point, as well as in determining the dependence on magnetic field, elastic strain, and temperature of magnetic and nonmagnetic phenomena in the neighborhood of the Curie point. The thermo-

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dynamic method enabled the researchers to show the effect of elastic strain on spontaneous magnetization and magnetostriction accompanying the paramagnetic process, and to establish more accurately the concept of the Curie temperature. The advantage of the thermodynamic method as compared with the model theories is that it can be applied to the analysis of data on all kinds of ferro- and ferrimagnets and that it reveals the basic characteristics in the behavior of ferro-, ferri-, and antiferromagnets in the neighborhood of the Curie point. The author thanks S. V. Vonsovskiy, Corresponding Member of the Academy of Sciences USSR, K. B. Vlasov, and A. A. Gusev. There are 244 references: 114 Soviet, 87 English, 25 French and 14 German.

TABLE OF CONTENTS:

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~~24 (8), 24 (3)~~

AUTHORS: Belov, K. P., Levitin, R. Z.

68049
SOV/55-59-3-17/32

TITLE: The Thermodynamic Theory of Antiferromagnetic Transformation

PERIODICAL: Vestnik Moskovskogo universiteta. Seriya matematiki, mekhaniki, astronomii, fiziki, khimii, 1959, Nr 3, pp 129 - 133 (USSR)

ABSTRACT: In the simplest case, an antiferromagnetic may be represented as consisting of two sublattices A and B, the specific magnetizations of which, without a field, are of the same value and of opposite direction. For the expansion of the thermodynamic potential near the Curie point

$$\Phi = \Phi_0(T) + \frac{\alpha_1}{2}(\sigma_A^2 + \sigma_B^2) + \alpha_2\sigma_A\sigma_B + \frac{\beta}{4}(\sigma_A^4 + \sigma_B^4) +$$

$$+ \frac{\gamma_1}{2}(\sigma_A^2 + \sigma_B^2)P + \gamma_2\sigma_A\sigma_B P - \frac{\mu}{2}P^2 - H(\sigma_A + \sigma_B)$$

holds in this case in consideration of elastic tensions. Here σ_A and σ_B denote the specific magnetizations of the sublattices, P - pressure; α_1, α_2, and β are the temperature-dependent coefficients;

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γ_1 and γ_2 are the magnetostriction constants, μ - the coefficient of elasticity. For reasons of simplicity, magnetic anisotropy is not taken into account. For the magnetization of antiferromagnetics near the Curie point $(\alpha_1 + \gamma_1 P)\sigma_A + (\alpha_2 + \gamma_2 P)\sigma_B + \beta\sigma_A^3 - H = 0$ and $(\alpha_1 + \gamma_1 P)\sigma_B + (\alpha_2 + \gamma_2 P)\sigma_A + \beta_B^3 - H = 0$ holds. Expressions are then derived for spontaneous magnetization and for the Curie point, for magnetic susceptibility, the discontinuity of specific heat, the spontaneous deformation of the lattice, the discontinuity of thermal dilatation, the discontinuities of the coefficient of compression from all sides, and the ratio between the discontinuities at Curie point. Checking of these relations is rendered difficult because of the lack of experimental data for the quantities ΔC, $\Delta\alpha$, $\Delta\varkappa$, etc. for one and the same sample. An approximate evaluation is, however, possible if the published data concerning measurements carried out on various samples are used. As an example, antiferromagnetic CoO is investigated. By using the aforementioned formulas, $\Delta C = 0.25$ kal/g.deg is obtained. For the Curie point shift due

to pressure $d\Theta/dP = 0.16$ deg./(kg/cm^2) holds. Thus, the Curie point of CoO shifts considerably more under the influence of pressure then in the case of ferromagnetics. In an antiferromagnetic $\gamma_1 - \gamma_2 = 3\Theta\alpha'_\Theta \Delta\alpha/\Delta C$ is found for the magnetostriction constant. For the thermodynamic coefficient α'_Θ one finds $\alpha'_\Theta = 0.53.10^2$ g/cm^3.deg. By substitution $\gamma_1 - \gamma_2 = 30.10^{-7}$ erg^{-2} is found. This does, however, not mean that the volume magnetostriction in CoO is also greater than in Invar-alloys. There are 8 references, 4 of which are Soviet.

ASSOCIATION: Kafedra obshchey fiziki dlya biologo-pochvennogo fakul'teta (Chair for General Physics for the Department of Biology and Soil Science)

SUBMITTED: March 3, 1959

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24 (C)

AUTHOR: Belov, K. P., Professor

SOV/30-59-10-44/51

TITLE: Ferromagnetic Semiconductors

PERIODICAL: Vestnik Akademii nauk SSSR, 1959, Nr 10, pp 108-109 (USSR)

ABSTRACT: The 3rd All-Union Conference was held in Minsk from June 1 to 7, 1959. It was devoted to problems of physics, physico-chemical properties, and physical fundamentals of the utilization of ferrites. Reports were submitted for the first time on the investigation of magnetic and electric properties of ferrite monocrystals. At the Institut kristallografii Akademii nauk SSSR (Institute of Crystallography of the Academy of Sciences, USSR) large ferrite monocrystals with a spinel structure are now being prepared. They are to provide the means of investigating the magnetic anisotropy, galvanomagnetic effects, ferromagnetic resonance, and the rotation of the polarization plane of electromagnetic waves. The Institut poluprovodnikov (Institute of Semiconductors), and the Physics Department of Moscow University, reported on the investigation of ferrites of rare-earth elements. The Conference discussed problems of the chemistry and technology of obtaining polycrystalline ferrites

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of high technical importance (Department of General Chemistry of Moscow University). The Akademiya nauk BSSR (Academy of Sciences, Belorusskaya SSR), and the Physics Department of Moscow University, reported on the static magnetic characteristics of ferrites with a rectangular hysteresis loop. The Institut fiziki metallov Akademii nauk SSSR (Institute of Metal Physics of the Academy of Sciences, USSR) reported on the investigation of the domain structure of barium ferrites. Further problems on the agenda concerned magnetic spectroscopy, magnetooptics, and the behavior of ferrites in superhigh frequencies. Reports were delivered by the Institute of Metal Physics and the Institute of Crystallography concerning the theory of antiferromagnetism and the magnetic anisotropy of ferrites. Finally, the author states with regret that the number of theoretical reports was very small, and that many theoretical questions remain as yet unanswered. The application of neutronographic methods to the investigation of atomic and magnetic structure in ferrite- and antiferromagnetic materials should be intensified.

24(3)
AUTHORS: Belov, K. P., Sirota, Z. D. SOV/56-36-4-14/70

TITLE: The Influence of the Atomic Ordering on Exchange Interaction in an Fe_3Pt-Alloy (Vliyaniye atomnogo uporyadocheniya na obmennoye vzaimodeystviye v splave Fe_3Pt)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 4, pp 1058-1062 (USSR)

ABSTRACT: The magnetic properties of Fe-Pt-alloys with a composition that is a near approach to Fe_3Pt have, especially within range of the Curie point, a number of characteristic features. A contribution is made by this paper toward the research of these properties by the investigation of the influence exercised by atomic ordering upon magnetostriction and the accompanying paraprocesses in such alloys. Already Belov (Ref 4) has shown that such an investigation of magnetostriction may furnish data on the connection between exchange interaction and interatomic distances. Samples consisting of 58% by weight of Pt and 42% by weight of Fe were investigated near the stoichiometric composition Fe_3Pt. The Kurnakov point of this alloy was

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between 900 - 1000°C. The samples had the shape of a bar of 150 mm length and 3 mm diameter. They were tempered at 1020°C in a vacuum furnace, after which they were chilled in water for the purpose of fixing the disordered state. The ordered state was established by annealing at 600°C over various periods of time (from 20 min to 12 hours). After each annealing the curve of the temperature dependence of magnetostriction was plotted (Fig 1); figures 2 and 3 show the course of these curves after annealing at 600°; they show the characteristic variations within the range of Curie point. Figure 4 shows the dependence of the spontaneous lattice deformation λ_s on the square of spontaneous magnetization σ_s. The course measured agrees with the thermodynamic theory according to which $\lambda_s = 1/6\gamma\sigma_s^2$ holds, where γ is the coefficient of spontaneous lattice deformation. Figure 5 shows the same as figure 4, but here the individual curves for each different period of annealing are given. λ increases linearly with increasing σ^2; this increase is all the more rapid, the shorter the time of

annealing, (i.e. the lower the ordering), but the steepness of the straight line does not decrease linearly with an increase of the duration of annealing. It further holds that $d\theta/dP = -\gamma/\alpha'_\theta$; α'_θ denotes derivation of the thermodynamic coefficient α according to temperature, determined from the curve of real magnetization near Curie point. Figure 6 shows the temperature dependence of α near the Curie point in the case of orderings of different magnitudes, i.e. annealing for different lengths of time. The last part of this paper deals with the determination of $d\theta/dP$. Figure 7 shows the dependence of the shifting of Curie point on pressure, as well as the dependence of the coefficient γ and of Curie temperature on the degree of ordering. It was found that atomic ordering varies not only the magnitude of exchange interaction, but that it also influences the nature of its dependence on interatomic distances. There are 7 figures and 6 references, 4 of which are Soviet.

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24(2), 24(3)

AUTHORS: Belov, K. P., Zaytseva, M. A., Malevskaya, L. A.

SOV/56-36-5-66/76

TITLE: The Magnetic- and Resonance Properties of the Ferrite Garnets of Yttrium in the Substitution of Fe^{3+}-Ions by Cr^{3+}- and Al^{3+}-Ions (Magnitnyye i rezonansnyye svoystva ferritov-granatov ittriya pri zameshchenii ionov Fe^{3+} ionami Cr^{3+} i Al^{3+})

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 5, pp 1602-1603 (USSR)

ABSTRACT: The present "Letter to the Editor" is in close connection with the preceding one (pp 1600-1601). The present letter deals mainly with the investigation of the influence exerted by foreign ions on the physical character. The stoichiometric compound $3Y_2O_3 \cdot 5Fe_2O_3$ is conveyed to $3Y_2O_3 \cdot (5-a)Fe_2O_3 \cdot aAl_2O_3$ and $3Y_2O_3 \cdot (5-a)Fe_2O_3 \cdot aCr_2O_3$ respectively by the substitutions. a denotes the content of Al^{3+} and Cr^{3+} ions. Measurements of the magnetic- and

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The Magnetic- and Resonance Properties of the Ferrite Granates of Yttrium in the Substitution of Fe^{3+}-Ions by Cr^{3+}- and Al^{3+}-Ions

SOV/56-36-5-66/76

resonance-characteristics were carried out on crystalline samples (sintering in air at 1300°C for 4 hours, density 2.75 g/cm^3). Figure 1 shows the connection between a and the saturation magnetization σ_o as well as between a and Curie point θ in the range $0 \leq a \leq 1$. All four curves (σ_o, θ for Al^{3+} and Cr^{3+}) show a more or less steep decline with increasing a, with the exception of the chromium-substituted sample which shows an incline at $a < 0.5$ for σ_o. Figure 2 shows the results obtained by measurements of the width of the absorption lines ΔH. With increasing a there is an increase of ΔH for the chromium-substituted sample, and a decrease for the Al-substituted sample. For the former the g-factor increases from 2.150 ± 0.005 (unsubstituted sample) to 2.200 ± 0.005, in the case of the latter it increases to 2.030 ± 0.005.

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The Magnetic- and Resonance Properties of the Ferrite Granates of Yttrium in the Substitution of Fe^{3+}-Ions by Cr^{3+}- and Al^{3+}-Ions

SOV/56-36-5-66/76

The ratios found agree qualitatively with the theory developed by Clogston et al. (Ref 4), i. e. that ΔH is proportional to $V\overline{\sigma_o}$ and θ. There are 2 figures and 4 references.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet (Moscow State University)

SUBMITTED: February 12, 1959

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24(3)

AUTHORS: Belov, K. P., Zaytseva, M. A., Ped'ko, A. V. SOV/56-36-6-7/66

TITLE: On the Magnetic Properties of Oxygen Compounds of Gadolinium (O magnitnykh svoystvakh okisnykh soyedineniy gadoliniya)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 6, pp 1672 - 1679 (USSR)

ABSTRACT: Considerable interest is at present being displayed in the magnetic properties of the oxides (ferrites) of rare earths. The authors of the present paper investigated the temperature dependence of the magnetic properties of various gadolinium oxides; the samples were of garnet- or perovskite structure and were, contrary to what was the case in earlier investigations (Refs 1,2) sufficiently large, so that the data obtained were more accurate. The samples were tempered in air at 900°C for 6 hours, pressed into shape (block 60.5.5 mm) under high pressure, after which they were again tempered for 4 hours at 1300°C. The magnetic properties were measured by ballistic, magnetometric and ponderomotoric means. Gandolinium ferrite garnets were subjected to the closest investigation. The authors operated with $3Gd_2O_3 \cdot 4.8Fe_2O_3 \cdot 0.2Y_2O_3$. They investigated saturation

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On the Magnetic Properties of Oxygen Compounds of Gadolinium

SOV/56-36-6-7/66

magnetization at helium temperatures and at Curie point (θ = 561°K), coercive force, magnetostriction, etc. The results obtained by the investigations are shown by numerous diagrams and are discussed in detail. Figure 1 shows the temperature dependence of specific magnetization at various field strengths (H= 25.8, 129 and 1550 Oe), figure 2 shows the temperature dependence of σ_s/σ_0 and of the residual magnetization σ_r/σ_0 within the range of compensation point, figure 3 shows the temperature dependence of the coercive force, and figure 4 the temperature dependence of the susceptibility of the paraprocess in $3Gd_2O_3 \cdot 5Fe_2O_3$; figure 5 shows the temperature dependence of magnetostriction, figure 6 the dependence of $(\sigma_s/\sigma_0)^2$ on (T/θ) within the range of the Curie point (straight line), and figure 7 the dependence of the magnetization on $H^{1/3}$ within the range of the Curie point. In a table the data of the garnet investigated are compared with those of other ferri- and ferromagnetics. It is found that at the compensation point and Curie point there is an anomalous growth of the coercive force and a very small paraprocess in garnet-ferrite and also an

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anomaly in the behavior of the temperature dependence of magnetostriction. Further results obtained by investigations concern gadolinium ferrite-perovskite $Gd_2O_3 \cdot Fe_2O_3$. Figure 8 shows the dependence of magnetization on the field (up to H= 7000 Oe) for various temperatures between 18 and 598°C, and figure 9 shows the analogous magnetization isothermal lines, but after heating beyond Curie point in the magnetic field. Figure 10 shows the temperature dependence of spontaneous magnetization in the magnetic field after the first and second heating (the curves differ considerably). It is found that perovskite gadolinium ferrite possesses a weak ferromagnetism of the hematite type. Finally, the results obtained by an investigation of gadolinium-manganite (perovskite) are described. Figure 11 shows the H-dependence of magnetization at various temperatures, and figure 12 the hysteresis in $Gd_2O_3 \cdot Mn_2O_3$ at 4.3°K, which may be observed within this temperature range although gadolinium manganite otherwise has paramagnetic properties. There are 12 figures, 1 table, and 6 references, 4 of which are Soviet.

24(3)

AUTHORS: Belov, K. P., Levitin, R. Z. SOV/56-37-2-42/56

TITLE: Magnetostriction of Antiferromagnetic Nickel Monoxide

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 37, Nr 2(8), pp 565-566 (USSR)

ABSTRACT: Information on the magnetostriction of antiferromagnetic substances has hitherto been scarce. It follows from general considerations (existence of a domain structure) that the magnetostriction of antiferromagnetics must be quite considerable and in any case stronger than in ordinary paramagnetics. The magnetostriction of polycrystalline NiO prepared by usual sintering methods was determined. In field not exceeding 7,000 Oe the susceptibility is only weakly dependent upon the field strength and amounts to 6.10^{-6}. The Curie-point was determined from the jump of Young's modulus to be 251°. These results correspond with those obtained by other authors (Ref 1). The magnetostriction was measured by means of a wire transducer, using a photo-electro-optical amplifier. In a diagram the transverse magnetostriction versus temperature function measured in a

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field of 14,200 Oe is given. This magnetostriction is negative and decreases monotonously on approaching Curie-point. In the second diagram the transverse magnetostriction versus field strength function is given for different temperatures, and the longitudinal magnetostriction at room temperature. The latter is positive. A certain "critical" field strength ($H_c \sim 5{,}000$ Oe) below which the magnetostriction is practically zero has been found. Only after surpassing this field strength does the magnetostriction begin to increase. According to the authors' opinion, the magnetostriction in antiferromagnetic nickel monoxide is caused by the existence of a domain structure. This is also indicated by a reduction of the effect with rising temperature and the different signs of the transverse and longitudinal effect. The existence of a critical field strength is, according to the authors, connected with the existence of a coercive force. A reduction of Young's modulus has also been found when a strong magnetic field was applied (antiferromagnetic ΔE effect). This also indicates the occurrence of magnetostriction in antiferromagnetic nickel monoxide. [redacted]

Moscow State U.

BELOV, K.P.; KATAYEV, G.I.; LEVITIN, R.Z.

Internal friction anomalies and modulus of elasticity in ferromagnetic materials near the Curie point. Zhur.eksp.i teor. fiz. 37 no.4:938-943 O '59. (MIRA 13:5)

1. Moskovskiy gosudarstvennyy universitet.
(Magnetism)

BELOV, K.P.; ZAYTSEVA, M.A.; KODOMTSEVA, A.M.

Characteristics of magnetic hysteresis phenomena in the systems $Pr_2O_3 \cdot Fe_2O_3$ and $La_2O_3 \cdot Fe_2O_3$. Zhur.eksp.i teor.fiz. 37 no.4:1159-1161 O '59. (MIRA 13:5)

BELOV, K. P.

PHASE I BOOK EXPLOITATION SOV/4893

Vsesoyuznoye soveshchaniye po fizike, fiziko-khimicheskim svoystvam ferritov i fizicheskim osnovam ikh primeneniya. 3d, Minsk, 1959

Ferrity; fizicheskiye i fiziko-khimicheskiye svoystva. Doklady (Ferrites; Physical and Physicochemical Properties. Reports) Minsk, Izd-vo AN BSSR, 1960. 655 p. Errata slip inserted. 4,000 copies printed.

Sponsoring Agencies: Nauchnyy sovet po magnetizmu AN SSSR. Otdel fiziki tverdogo tela i poluprovodnikov AN BSSR.

Editorial Board: Resp. Ed.: N. N. Sirota, Academician of the Academy of Sciences BSSR; K. P. Belov, Professor; Ye. I. Kondorskiy, Professor; K. M. Polivanov, Professor; R. V. Telesnin, Professor; G. A. Smolenskiy, Professor; N. N. Shol'ts, Candidate of Physical and Mathematical Sciences; E. M. Smolyarenko; and L. A. Bashkirov; Ed. of Publishing House: S. Kholyavskiy; Tech. Ed.: I. Volokhanovich.

PURPOSE: This book is intended for physicists, physical chemists, radio electronics engineers, and technical personnel engaged in the production and use of ferromagnetic materials. It may also be used by students in advanced courses in radio electronics, physics, and physical chemistry.

COVERAGE: The book contains reports presented at the Third All-Union Conference on Ferrites held in Minsk, Belorussian SSR. The reports deal with magnetic transformations, electrical and galvanomagnetic properties of ferrites, studies of the growth of ferrite single crystals, problems in the chemical and physicochemical analysis of ferrites, studies of ferrites having rectangular hysteresis loops and multicomponent ferrite systems exhibiting spontaneous rectangularity, problems in magnetic attraction, highly coercive ferrites, magnetic spectroscopy, ferromagnetic resonance, magneto-optics, physical principles of using ferrite components in electrical circuits, anisotropy of electrical and magnetic properties, etc. The Committee on Magnetism, AS USSR (S. V. Vonsovskiy, Chairman) organized the conference. References accompany individual articles.

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AUTHORS: Belov, K.P. and Nikitin, S.A.

TITLE: Study of the Low-temperature Transformation in a Crystal of Manganese Ferrite

PERIODICAL: Kristallografiya, 1960, Vol. 5, No. 5, pp. 726 - 731

TEXT: At about -75 °C in a single crystal of manganese ferrite anomalies in the curves of electrical resistance and galvanomagnetic effect against temperature have been discovered. These must be connected with the existence of a low-temperature transition. The electrical and magnetic properties of manganese ferrite change less sharply than those of magnetite at this transition. From the energy of activation it is suggested that the low-temperature transition is connected with the exchange of electrons between manganese ions.
It has been suggested by Verwey that the low-temperature transition observed in magnetite is due to the ordering of the two- and three-valent iron ions in the octahedral positions caused by the exchange of electrons (electron diffusion).
Single crystals of the ferrites $MnO.Fe_2O_3$ and Fe_3O_4 were made

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by the Verneuil process. They were rods about 35 cm long and 5 mm in diameter. The rod axis was [111], the direction of easy magnetisation. Electrical contacts were made with silver paste. A vacuum of better than 10^{-2} mm Hg was maintained in the cryostat. The values for the activation energy of the manganese ferrite of 0.27 and 0.21 eV determined from the temperature dependence of the conductivity agree with the value of 0.3 eV found by Gibbons (J. Appl. Phys., Vol. 28, 810, 1957) determined from the temperature dependence of the coefficient of internal friction. In magnetite this energy is less than 0.04 eV. In the manganese ferrite, besides the exchange of electrons between Mn^{+4} and Mn^{+3} ions there is also the possibility of the formation of Mn^{+3} ions.

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AUTHORS: Belov, K.P., Belov, V.F. and Timofeyeva, V.A.

TITLE: Ferromagnetic Resonance in Single Crystals of Yttrium Ferrite in the Temperature Range from Room Temperature to the Curie Point

PERIODICAL: Kristallografiya, 1960, Vol. 5, No. 5, pp. 732 - 736

TEXT: The temperature dependence of the parameters of the ferromagnetic resonance in single crystals of yttrium ferrite (garnet) from 20 to 300 °C has been measured. With increasing temperature the constant of the magnetic anisotropy (K_1) decreases but the g-factor scarcely changes. The resonant absorption line width H also decreases but grows again towards the Curie point. The effect of the different degrees of polishing on the line width was also studied. Crystals were grown by the method of Nielsen and Dearborn (J. Phys. Chem. Solids, Vol. 5, 202, 1958) in the form of tetrakis trioctahedra or of combinations of this form with the rhombic dodecahedron. These were ground into spheres of 0.8 to 1.0 mm diameter and

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Ferromagnetic Resonance in Single Crystals of Yttrium Ferrite in the Temperature Range from Room Temperature to the Curie Point

measurements were made at 9470 Mc/s. The spheres were oriented magnetically and mounted in a resonance chamber. With the size of sphere used, produced by air grinding, there was no correction for the size of the sphere. The surface finish, however, seriously affected the line width and the final polishing paper had a grain size of 1 μ. If the polishing powder had a grain size of 100 μ then the line width was 15 Oe but with the finest grinding this was reduced to 2.3 Oe. The Landé g-factor was found, as was expected from spectroscopic data, to be slightly different from 2 . On three specimens it was measured as 2.03, 2.02 and 2.01 in each case ± 0.003. The resonance magnetic field for the three directions [100], [110] and [111] approached each other from the values of 3450, 3347 and 3313 Oe, respectively, at 20 °C and converged to the value 3364 Oe at 250 °C.

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AUTHORS: Belov, K.P. and Nikitin, S.A. 21

TITLE: Temperature Dependence of Spontaneous Magnetization in a Monocrystal of a Manganese Ferrite in the Low Temperature Region 21 21

PERIODICAL: Fizika metallov i metallovedeniye, 1960, Vol 9, Nr 3, pp 470-472 (USSR)

ABSTRACT: Recent work (Ref 1 to 5) on the quantum mechanical theory of the temperature dependence of spontaneous magnetization in the case of ferrites near 0°K has led to conflicting results. In most cases a $T^{3/2}$ law was obtained while in others the law was found to be T^2. On the other hand, Tyablikov (Ref 3) has shown that either of these two laws may hold, depending on the origin of the magnetic non-equivalence of the sub-lattices. The present paper reports results of measurements of the spontaneous magnetization of a monocrystal of manganese ferrite, in the temperature region 4.2°K to room temperature. The monocrystal was in the form of a cylinder 35 mm long and 5 mm in diameter. It was grown by A.A.Popova (Ref 7). The easy

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