la (24), in which the function D^-_{sur} is expressed in terms of the correlator

$$iD^-_{sur}(rt,r't')=\left\langle \sum_{jj'} V(r-r_j)V(r'-r_{j'}) \right\rangle,$$

which contains averaging over the configurations of the impurities r_j.

In conclusion I express my gratitude to A. A. Abrikosov and I. M. Lifshitz for a discussion on the work and important comments.

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Translated by P. J. Shepherd

Interaction of Bloch walls with dislocations in garnet films possessing a cylindrical domain structure

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(Submitted 5 October 1978)
Zh. Eksp. Teor. Fiz. 76, 1369–1380 (April 1979)

The dislocation and domain structures of monocrystalline films of $(YBi)_3(FeGa)_5O_{12}$, grown on gadolinium-gallium garnet plates, are investigated by an optical polarization method and by selective chemical etching. The interaction with dislocations is studied for walls of stripe domains in a labyrinth structure and of cylindrical magnetic domains. For the first time, a direct experimental investigation is carried out of the potential contours for the motion of a 180° Bloch wall in the microstress field of an individual dislocation. The forces exerted by the dislocation on individual elements of the domain wall are measured. A theoretical calculation is made of the potential and forces of magnetoelastic interaction of various sections of the domain wall with the internal-stress field of the dislocation. The experimental data are compared with the calculation and with the predictions of current theories. The comparison reveals some peculiarities not considered earlier in the kinetics of the surmounting by a wall of potential barriers due to dislocations.

PACS numbers: 75.70.Kw, 75.50.Gg, 61.70.Yq

INTRODUCTION

Study of the role of defects of the crystal lattice of a ferromagnetic material in the formation of its domain structure and in the kinetics of change of that structure is necessary for creation of a systematic theory of the magnetization of real magnetically ordered materials. Special interest attaches to the explanation of the nature of the interaction of domain walls with dislocations, the longest-range sources of internal stresses. Use of an optical polarization method for solution of this problem made it possible for the first time to carry out direct experimental investigation of the influence of individual dislocations on elementary events of the magnetization process[1,2] in the example of monocrystals of yttrium-iron garnet. Comparison of experimental data with the predictions of current theories revealed basic contradictions between them. In particular, it was found that in a real crystal the interaction of a Bloch wall with a dislocation begins at distances far exceeding the thickness of the wall. During the process of their interaction, new domains originate in the dislocation-microstress field and at the wall. These data were obtained on a many-axis ferrimagnet, characterized by appreciable anisotropy of the energy of a Bloch wall,[3] under conditions of motion of several walls through the specimen and presence of surface closure domains. It might be supposed that the regularities observed were characteristic solely of crystals whose magnetic structure allows formation of new domains magnetized in a direction not coinciding with the magnetization of the main domains. In order to elucidate the reasons for the disagreement between experimental data and theory, it was of interest to investigate also the anisotropy of the interaction of dislocations with a Bloch wall under conditions when its energy is independent of the direction of its normal to the plane perpendicular to the wall.

The present communication presents the results of a study of the regularities of the motion of a 180° domain wall in the elastic field of an individual dislocation in magnetically uniaxial, epitaxial films of $(YBi)_3(FeGa)_5O_{12}$.

In these materials, as is well known,[4] surface closure domains do not occur. Furthermore, in this crystal it is possible, by means of a magnetic gradient field, to produce a single plane 180° wall[5] in an arbitrary position with respect to the glide plane of a dislocation, and thus to investigate the anisotropy of the potential contours produced by a dislocation for motion of a domain wall in a ferromagnetic material.

It must also be mentioned that elucidation of the role of defects of the crystalline lattice in the determination of the laws of generation and propagation of magnetic domains in ferrimagnetic films has in recent years acquired, besides its purely scientific interest, a high direct practical importance in connection with the possibilities for use of cylindrical magnetic domains (bubbles) as carriers of information in various systems for processing and storing it for computers.[4]

EXPERIMENTAL METHOD

The investigations were made on films of $Y_{2.7}Bi_{0.3}Fe_{3.8}Ga_{1.2}O_{12}$ of thickness 10 μm, grown by the method of liquid-phase epitaxy on monocrystalline plates of gadolinium-gallium garnet (GGG) bounded by {111} planes. The saturation magnetization of the films had a value ~24 G, the uniaxial-anisotropy field ~900 Oe.

The internal stresses and dislocations in the substrate and in the film were studied by the photoelastic method. Investigation of the character of the macroscopic stresses in GGG crystals grown by the Czochralski method showed that they did not originate as a result of the occurrence of processes of plastic shear in the field of thermoelastic stresses developed during the growth or cooling of the slug. As in Ref. 6, the principal factor determining the formation of a defect structure of GGG was an enhanced content of certain impurities in the melt. They not only precipitated as inclusions but also stimulated the formation of a complicated and distinctive dislocation structure. Its formation required more than just the additional stress concentration at the inclusions; a no less decisive contribution was made by diffusion processes. Formation of precipitations of a foreign phase was accompanied by generation of a high concentration of characteristic point defects, appreciably exceeding the thermodynamic equilibrium concentration. This stimulated the operation of sources of the Bardeen-Herring type, the curling of screw dislocations into helicoids, and the formation of prismatic loops. Some of the dislocations of the substrate were inherited by the film.

The investigation of the interaction of dislocations with Bloch walls was done on dislocations perpendicular to the film surface. In polarized light, one observed around them a characteristic[7] rosette of anomalous birefringence, from which it was easy to determine the {110} glide plane of the dislocations. The minimal translation vector in the garnet lattice is directed along ⟨111⟩. It is therefore most probable that the dislocations had a 71° orientation with respect to the Burgers vector. Exit of the dislocations to the crystal surface was also monitored by the etching pattern, for when the nicols are uncrossed to expose the domain structure the birefringence rosettes around the dislocations are poorly visible against the background of intense transillumination of the crystal because of the Faraday effect. Additional investigations of the behavior of domain walls near dislocations, on crystals with dislocations chemically etched and unetched, showed that the fine etching pits do not introduce significant changes in the character of the interaction of dislocations with walls.

The study of the domain structure was accomplished by a magneto-optic method.[1] A plane 180° domain wall was produced in the crystal by a magnetic gradient field from an electromagnet with shaped pole pieces.[5] Displacement of it through the specimen occurred on motion of the crystal with respect to the magnet gap. Cylindrical magnetic domains (bubbles) were generated by the traditional method.[4] Their coercivity was measured in a gradient field by use of parallel conductors.[8]

EXPERIMENTAL RESULTS

Figure 1 shows the character of the change, under the influence of a magnetic field, of the original domain structure in a film containing dislocations. The etching patterns (light circles) indicate exits of dislocations to the surface of the film. The demagnetized state (Fig. 1) is characterized by the typical labyrinth domain structure. It is clearly evident that the dislocations very strongly influence the laws of its formation. The configuration of the domain wall in the center of the photograph is completely determined by the series of dislocations. Most of the dislocations are located not inside domains but on Bloch walls, which they pin. Upon application of an external magnetic field perpendicular to the surface of the plate, stripe domains magnetized opposite to the field begin to thin and shorten by motion of walls that are not trapped by dislocations.

The character and strength of the interaction of dislocations with walls of stripe domains depend both on the orientation of the Bloch walls with respect to the glide plane of the dislocation and on the direction of their displacement. In Fig. 2 it is seen that only certain walls are so strongly pinned by dislocations (dark circles) that on increase of the external field, a stripe domain shortens, contracting to a bubble connected with a dislocation. The value of the field at which a Bloch wall breaks away from a dislocation is dependent also on the surrounding domain structure because of the existence of dipole interactions between the domains. The mutual repulsion of the domains led to displacement of the whole stripe domain indicated by the arrow in Fig. 2b and facilitated the breaking away of its wall from the dislocation. As is well known, in defectless crystals, because of the dipole interaction between bubbles, they locate themselves at sites of a hexagonal lattice. Dislocations

FIG. 1. Pinning by dislocations (light circles) of walls of stripe domains of a film in the demagnetized state.

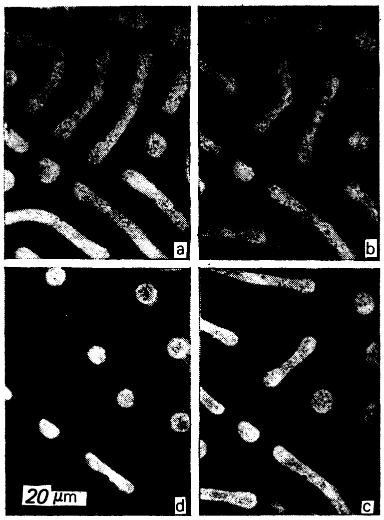

FIG. 2. Effect of dislocations on the process of formation and motion of a bubble.

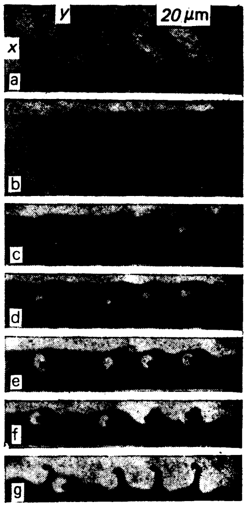

FIG. 3. Change of shape of an isolated 180° Bloch wall during displacement of it (from top to bottom) with respect to dislocations (dark circles), in a direction parallel to their glide plane (b – g); a, birefringence rosette around dislocations in a magnetized crystal.

(depending on their density) may not only change the period of the lattice, but completely destroy the regularity.

In the measurement of the coercive force produced by a dislocation for displacement of a bubble in a magnetic gradient field, the influence of the potential contours due to dislocation microstresses showed up also in the fact that the direction of motion of a domain that had broken away from a dislocation did not in general coincide with the direction of the gradient of the magnetic field. It depended also on the character of the arrangement of the surrounding domains. The coercive force for bubble displacement in the field of a dislocation had a value of 0.1–0.2 Oe, whereas in dislocation-free sections it was orders of magnitude smaller.

Measurement of the anisotropy and strength of the interaction of a stripe-domain wall with dislocations was also complicated by the impossibility of taking into account the effect of the whole aggregate of domains on the pinning of a Bloch wall. It was therefore advisable to make such measurements on an isolated domain wall, the only one in the whole crystal, produced by a gradient field. Here there also appeared a unique opportunity for detailed study of the anisotropy of the potential contours for motion of a Bloch wall in a dislocation microstress field.

Figure 3 shows an example of interaction of a plane 180° Bloch wall (in the photograph, it separates the dark and light domains, and in its original position it is located in the section of the crystal where the gradient of the magnetic field changes sign) with single dislocations (dark circles) whose glide plane is perpendicular to the plane of the wall. The series of photographs from *b* to *g* shows a sequence of changes of shape of the wall as it moves with respect to the dislocations (from top to bottom) during motion of the specimen in a magnetic gradient field. The interaction of the Bloch wall with a dislocation shows up long before approach of the wall to the core of the dislocation. At some distance between them, the wall begins to bend appreciably. The field of the dislocation microstresses tends to turn the wall and to orient it along the glide plane of a dislocation. On further displacement of the wall toward the dislocation, there appears at the latter a new microdomain (the white spot near the extreme right dislocation etch pit in Fig. 3c), with magnetization antiparallel to the magnetization of the contracting macrodomain. With decrease of the distance between the dislocation and the wall, the new domain grows (Fig. 3d), acquiring a cylindrical shape (Fig. 3e); and it becomes clear that it is located to the left of the glide plane, in the region of tensile stress σ_x. In these figures one clearly observes the result of dipole interaction between the approaching macrodomain and the new domain that has appeared at the dislocation. The repulsive forces acting between them roll the microdomain around the point where its wall is pinned by the dislocation.

Thereafter the two light domains fuse (Fig. 3f), the Bloch wall bends around the dislocation, and on it is formed a bulge located in the sections where compressive stresses σ_x act. With subsequent advance of the wall, the bulge lengthens; and at a certain critical distance d_c between the dislocation and the wall, it discontinuously breaks away from the point of pinning. From the critical length of the bulge and the known gradient of the magnetic field dH_z/dx, one can determine the coercive force H_c. In the case shown in Fig. 3 ($d_c = 8$ μm, $dH_z/dx = 0.6$ Oe/μm), $H_c = (dH_z/dx)d_c \approx 5$ Oe. It was practically (within the limits of scatter of the experimental data, ~50%) independent of the value of the magnetic field gradient. If, at breakaway of the bulge, the wall was located at a sufficiently small distance from the dislocation (i.e., for large values of dH_z/dx), then there remained a microdomain near the core of the latter.

In reverse motion of a wall, the rules of interaction of it with a dislocation were observed to be qualitatively as in Fig. 3. The section of the wall opposite the dislocation was turned by its elastic field in the same direction as in the first case, a new microdomain originated in the region of action of compressive σ_x, and later it fused with the bulge of the approaching macrodomain.

If the initial orientation of the Bloch wall with respect to the glide plane of the dislocation was changed (by rotation about z), the character of the distortion of shape of the wall during its displacement past the dislocation changed significantly. Figure 4 shows the interaction of a 180° wall with a dislocation when the glide plane of the dislocation and the plane of the wall in the starting position are almost parallel to each other. In this case there is also clearly observed (by comparison of Figs. 4 *b-g* and Figs. 4 *b′-g′*) an asymmetry of the character of the interaction of the Bloch wall with the dislocation with respect to the direction of motion of the wall. On displacement of the wall from the side of the extra half-plane from right to left (Figs. 4 *b-g*), the effect of the dislocation stress field begins to be detected, just as in Fig. 3, at considerable distances from the core of the dislocation. The retarding effect of the dislocation on the moving wall shows up more sharply. As a result, there forms on the dark domain a bulge (Figs. 4 *c-e*) which, with advance of the wall to the left, contracts to a cylindrical domain (Fig. 4 *f*). It remains in the field of compressive stresses σ_x, and the wall discontinuously surmounts the dislocation. On increase of the distance between them, the diameter of the bubble decreases, and it disappears. Measurements under these conditions gave the value $H_c = 2$ to 3 Oe.

In reverse motion of the wall, its interaction with the dislocation begins at smaller distances than in the previous case (Figs. 4 *b′-g′*). The retarding effect of the stresses on approach to the dislocation is practically unobservable. The bubble is formed in front of the moving wall (Fig. 4 *d′*), on the side of the extra half-plane appropriate to the dislocation. With advance of the wall to the right, the size of the bubble increases. Then it discontinuously fuses with the macrodomain (Fig. 4 *f′*), and the wall surmounts the dislocation.

Change of the sign and value of the gradient of the external field, within limits that insured retention of the plane form of the domain wall, led to no substantial change of the basic features of the interaction shown in Figs. 3 and 4.

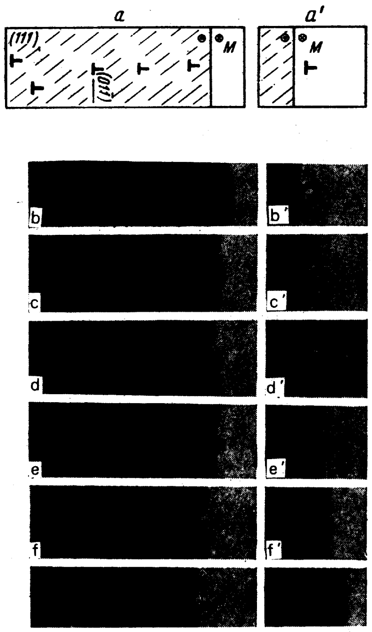

FIG. 4. Change of shape of a 180° Bloch wall during displacement of it from right to left (b – g) and from left to right (b′ – g′) in the elastic field of a single dislocation, whose glide plane is parallel to the domain wall in the initial state.

DISCUSSION OF RESULTS

In the nonuniform internal-stress field of the dislocations, different forces act on different sections of the domain wall, and this promotes a change of its shape. Bending of the wall is opposed by the forces of surface tension. In general, on bending of the wall magnetic charges appear on its surface. Under the experimental conditions described earlier,[2] when M in the adjacent domains was perpendicular to the dislocation, they produced such high stiffness of the Bloch wall that no bending of it was detected. On approach of the wall to the core of the dislocation, new microdomains originated at the domain wall and at the dislocation.

In the experimental situation used in the present research, the magnetic moments M in the adjacent domain (Fig. 5) are parallel both to the dislocation (located along the z axis, perpendicular to the plane of the drawing) and to the 180° Bloch wall. Bending of the domain wall around M is not accompanied by appearance of magnetic charges and increase of the magnetostatic energy of the wall. Bending of the wall in the nonuniform internal-stress field of the dislocation is possible. Its character is directly determined by the character of the distribution of the forces that act on individual elements of the Bloch wall.

Two methods have so far been developed for calculating the forces of interaction between dislocations and domain walls. One of them[9] is based on calculation, by the Peach-Koehler formula, of the force exerted on the dislocation by the magnetostrictive stresses produced by the nonuniform magnetization distribution in the wall. In the second method,[10,11] one calculates first the potential $W(x, y)$ of interaction of the domain wall with the dislocation, and then the force from the change of the

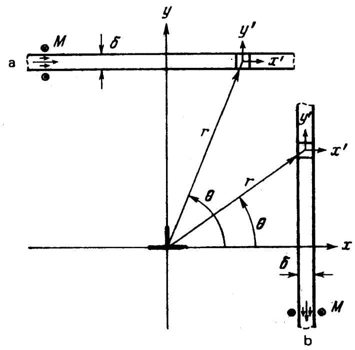

FIG. 5. Calculation of energy and forces of interaction of a dislocation with a 180° Bloch wall.

potential in the direction l of motion of the wall: $F_l = -\partial W(x, y)/\partial l$.

Use of the method of Ref. 9 makes it possible to calculate quite simply the total force exerted by a dislocation on the whole domain wall. Application of it for calculation of the interaction with a Bloch wall perpendicular to the Burgers vector (Fig. 3) gives a zero value for the force acting on the whole wall. In the case of a wall parallel to the glide plane of the dislocation (Fig. 4), theory[9-11] predicts existence of an interaction of a 190° domain wall with a dislocation only when the latter is located inside the wall. The experimentally observed appreciable effect of the dislocation on the Bloch wall is determine d by local forces acting on individual elements of the wall; it does not seem possible to calculate these by use of the method of Ref. 9. It is the diversity of these forces that also determines the shape of the Bloch wall in the experiment being discussed. Therefore in order to estimate the character of the behavior of a wall near a dislocation we use the method of Vicena.[10] In contrast to Vicena, we shall not integrate the magnetoelastic energy density over the coordinate of a volume element that determines its position along the wall. In this case one gets a result that agrees with that obtained by the previous method[9] and that describes the total enegry, determined by the action of the forces on the whole wall. We shall calculate the magnetoelastic energy of unit area of a plane Bloch wall when its center has coordinates (r, θ) in a reference system attached to the dislocation (Fig. 5).

An edge dislocation parallel to the vector spontaneous magnetization does not lead[10,12] to the appearance of magnetic stray fields in the surrounding crystal. In this case the potential of interaction of the Bloch wall with the dislocation is completely determined by its magnetoelastic energy in the dislocation stress field, whose density in the isotropic-magnetostriction approximation is described by the following expression:

$$\omega(x, y) = -\frac{3}{2}\lambda[\alpha^2\sigma_x+\beta^2\sigma_y+\gamma^2\sigma_z+2\alpha\beta\sigma_{xy}+2\alpha\gamma\sigma_{xz}+2\beta\gamma\sigma_{yz}], \quad (1)$$

where λ is the magnetostriction constant and α, β, and γ are the direction cosines of the magnetic moment.

In the microstress tensor of an angle dislocation, only four components are nonzero:

$$\begin{aligned}
\sigma_x &= -D\frac{y(3x^2+y^2)}{(x^2+y^2)^2} = -\frac{D}{r}\sin\theta(2+\cos 2\theta),\\
\sigma_y &= D\frac{y(x^2-y^2)}{(x^2+y^2)^2} = \frac{D}{r}\sin\theta\cos 2\theta,\\
\sigma_z &= -2D\nu\frac{y}{x^2+y^2} = -\frac{2D\nu}{r}\sin\theta,\\
\sigma_{xy} &= D\frac{x(x^2-y^2)}{(x^2+y^2)^2} = \frac{D}{r}\cos\theta\cos 2\theta,
\end{aligned} \quad (2)$$

where $D = Gb/2\pi(1-\nu)$; G is the shear modulus, b is the Burgers vector of the dislocation, and ν is Poisson's ratio. For a domain wall parallel to the glide plane of the dislocation (Fig. 5a), $\alpha = \cos\varphi$, $\beta = 0, \gamma \sin\varphi$ (φ is measured from z):

$$\omega(x, y) = -\frac{3}{2}\lambda(\sigma_x\cos^2\varphi+\sigma_z\sin^2\varphi). \quad (3)$$

The magnetoelastic energy, per unit length of the dislocation, of an element of a 180° Bloch wall, of unit width and of thickness δ, is

$$W(x, y) = -\frac{3}{2}\lambda\int_{-\pi/2}^{\pi/2}(\sigma_x\cos^2\varphi+\sigma_z\sin^2\varphi)\,d\varphi. \quad (4)$$

If we approximate the actual distribution law of the magnetization in the wall, $\sin\varphi = \tanh(y/\delta)$, with the linear function $\varphi = (y'-y)\pi/\delta$, and if we take into account that for $r \gg \delta$ the values of σ_x and σ_y vary insignificantly within the chosen volume element and are equal on the average to their values at the point with the coordinates (r, θ) of its center, then after integration we get

$$W(x, y) = -A\frac{y[(3+2\nu)x^2+(1+2\nu)y^2]}{(x^2+y^2)^2} = -\frac{A}{r}\sin\theta[2(1+\nu)+\cos 2\theta], \quad (5)$$

where $A = -3\lambda\delta D/4$. Hence the force acting on a volume element of the wall located at (x, y), when the wall moves along y, is

$$\begin{aligned}
F_y &= -\frac{\partial W(x, y)}{\partial y} = A\frac{2x^2(x^2-3y^2)+(1+2\nu)(x^4-y^4)}{(x^2+y^2)^3}\\
&= \frac{A}{y^2}\sin^2\theta\{2\cos 2\theta[(1+\nu)+\cos 2\theta]-1\}.
\end{aligned} \quad (6)$$

Analogously we can show for the second case (Fig. 5b), when the Bloch wall at infinity is perpendicular to the Burgers vector, that

$$W(x, y) = A\frac{y[(1-2\nu)x^2-(1+2\nu)y^2]}{(x^2+y^2)^2} = \frac{A}{r}\sin\theta(\cos 2\theta-2\nu), \quad (7)$$

$$\begin{aligned}
F_x &= -\frac{\partial W(x, y)}{\partial x} = \frac{2Axy}{(x^2+y^2)^3}[(1-2\nu)x^2-(3+2\nu)y^2]\\
&= -\frac{A}{x^2}\cos^2\theta\sin 2\theta[(2\nu-1)\cos^2\theta+(2\nu+3)\sin^2\theta].
\end{aligned} \quad (8)$$

Figures 6 and 7 show equipotentials of a Bloch wall in the microstress field of a dislocation, and graphs of the distribution along the wall of the forces acting, along the direction of motion, on various sections of the wall, for the two situations studied experimentally (Figs. 3 and 4). Analysis of them shows that the shape of curved walls located at appreciable distances from the core of the dislocation (Figs. 3c and 4c) is in qualitative agreement with the nature of the distribution of the forces acting on it. In the experiment shown in Figs. 3 and 4, the additional small-amplitude bending of the wall for the sections located near $y = 0$ and $x = 0$ respectively, expected from the behavior of $F_x(y)$ and $F_y(x)$ (Figs. 6 and 7), does not show up. Apparently it is smoothed out by the forces of surface tension of the film. But it is evident that the general character of the change of shape of walls and its anisotropy (dependence on the mutual arrangement of the dislocation and the wall) are determined by the local forces of magnetoelastic interaction of individual wall elements with the dislocation microstress field. For example, it follows from Fig. 6 that the largest forces of interaction correspond to sections of the wall with $y \neq 0$. From Figs. 3f and g it is seen that the bulge on the contracting (dark) domain is located to one side of the glide plane and extends along y to an appreciable distance from the core of the dislocation.

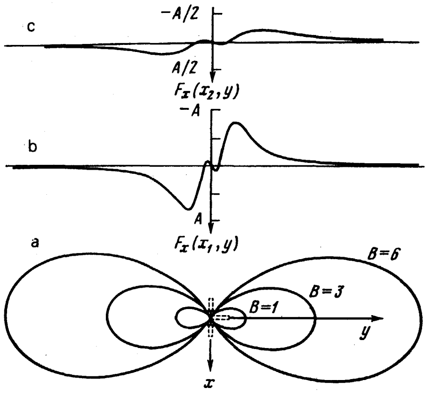

FIG. 6. Contours of the energy of interaction of an edge dislocation with a domain wall perpendicular to the glide plane of the dislocation, plotted from (7): $B=A/W(x,y)$ (a). Graphs of the variation of the forces $F_x(y)$, plotted from (8), for a Bloch wall located at two different distances x_i from the dislocation: $|x_1|<|x_2|$ (b, c).

This qualitative agreement of the wall shape and the character of the distribution of the forces acting on it persists with approach of the wall to the dislocation, until the moment when the core of a cylindrical domain originates near the dislocation core.

The necessity for formation of a new domain at the dislocation on approach of the Bloch wall to it has not been predicted by current theories. It also does not follow directly from the estimates presented. But from the form of the $F_y(x)$ graph (Fig. 7), one may assume the following mechanism of formation of a new domain. In the absence of the dislocation, the domain wall is plane, and its projection on a plane perpendicular to the z axis is described by the equation $y=y_0$. If we place at the point $x, y=0$ the core of a dislocation with Burgers vector along x, then under the action of the forces $F_y(x)$ the domain wall bends. On it a bulge appears, consisting of wall sections whose projections make angles with the x axis, equal in the limiting case to 90°. It is important that in this case there are formed wall elements having a component perpendicular to x and free to move along the x axis under the influence of the forces $F_x(y)$ exerted by the external field. If the wall elements

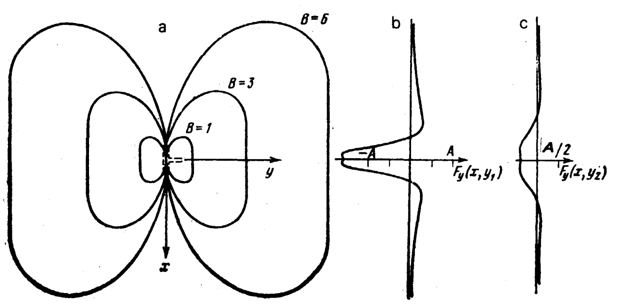

FIG. 7. Contours of the energy of interaction of an edge dislocation with a domain wall parallel to the glide plane of the dislocation, plotted from (5): $B=A/W(x,y)$ (a). Graphs of the variation of the forces $F_y(x)$, plotted from (6), for a Bloch wall located at two different distances y_i from the dislocation: $y_1 < y_2$ (b, c).

that have appeared move toward each other, flowing around sections of the crystal characterized by a high value of the forces $F_y(x)$ and stopping sections of the wall $y=y_0$, then upon their annihilation there is formed a closed wall, bordering a region of the ferromagnet magnetized in the direction of the contracting domain (the cylindrical microdomain in Fig. 4). We point out that in this case the mechanism of formation of a microdomain at a dislocation differs from the one that we described earlier.[2] Under the experimental conditions of Ref. 2, the dislocation was perpendicular to the direction of the magnetic moments in the adjacent domains, and the 180° Bloch wall moved in undiluted yttrium iron garnet (magnetically a many-axis material). Then magnetic charges appeared on the domain wall when it bent, and the microstresses of the dislocations produced a stray field that could given an energy advantage to a direction of easy magnetization other than that in the macrodomains. In the present experiment, a dislocation does not produce magnetic charges, and neither of the magnetic-moment directions in the domains shown in Figs. 3 and 4 is distinguished by an energy advantage.

Proof of the occurrence of this mechanism can be discerned in the experiments with labyrinth and cylindrical-domain structures. In the interaction of the walls of stripe and cylindrical domains with dislocations when the crystal is magnetized by a uniform magnetic field, bending of 180° Bloch walls is practically unobservable. The reason for this is the operation of the mechanism being discussed, which is determined by the presence of wall sections capable of moving easily in a direction perpendicular to the direction of motion of the main wall. Such variation of the shape of the wall insures a minimum of the energy of the whole system and the fastest growth of the energetically favored domain. Figure 8 shows steps in the process of magnetization of a stripe domain of a labyrinth structure, one of whose walls is encountering resistance to its motion by a series of dislocations. In small external magnetic fields, the long lower section of the wall of the stripe domain, parallel to the horizontal frame of the figure, is pinned by dislocations and does not move. Magnetization of the crystal occurs because of the short vertical sections of the wall, which move along y toward each other under the influence of the external magnetic field.

The potential contours of the wall in the field of the set of dislocations are such that the resulting forces $F_x=-\partial W(x,y)/\partial x$ opposing motion of the long section of the wall along x significantly exceed the forces $F_y=-\partial W(x,y)/\partial y$ opposing motion of a perpendicular element of the wall in the y direction. This mechanism of motion of a

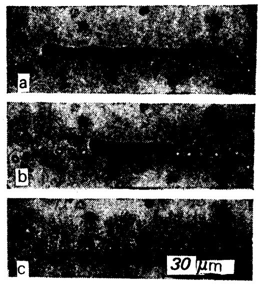

FIG. 8. Decrease of the volume of a stripe domain pinned by dislocations (light circles) under the action of an external magnetic field, by motion of the vertical sections of its wall.

wall in an external magnetic field is similar to the mech mechanism of motion of dislocations in a Peierls potential or of dislocations perpendicular to the wall.[13]

CONCLUSION

Thus in the experiment described, it has been possible for the first time to bring about a situation that permits direct experimental study of the potential and forces of interaction of dislocations with a 180° Bloch wall, and qualitative comparison of the experimental results with the predictions of a theory that describes the magneto-elastic interaction of a domain wall with the microstress field of dislocations. A quantitative test of the predictions of the theory requires knowledge of the magnetostrictive constants of this material, and also a rigorous solution of the problem of the shape of the wall in the potential field, with allowance for surface-tension forces, for the external magnetic-gradient field, and for the change of the law of distribution of the magnetic moment in the Bloch wall under the influence of the stresses from the dislocation, as well as the finiteness of the dimensions of the crystal in a direction perpendicular to the dislocation line. Finally, the investigations have shown that by analyzing the nature of the interaction of a Bloch wall with an edge dislocation, one can determine the sign of its Burgers vector for known magnetostriction constants, or their signs for a known direction of the Burgers vector.

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Translated by W. F. Brown, Jr.