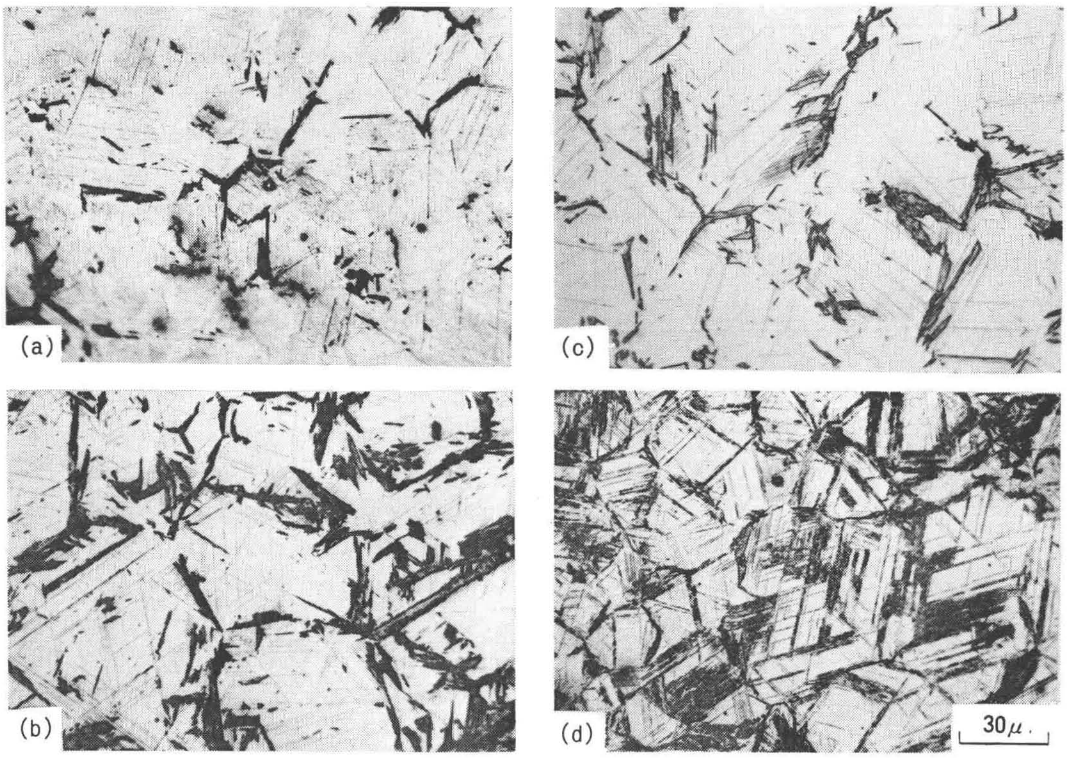

Photo. 8. Change of martensite structure in Fe-0.42%C (A-4) ((a) and (b)) and Fe-0.35%C-1.51%Si (S-3) ((c) and (d)) alloys at 38.5kbar, quceched to (a) 160°C, (b) 140°C, (c) 200°C and (d) 160°C.

$^{\gamma\rightleftarrows\alpha}$, $T_0{}^{\gamma\rightleftarrows\varepsilon}$ and $T_0{}^{\varepsilon\rightleftarrows\alpha}$, which were determined on the basis of the thermodynamic analysis. It means that phases have the equal free energy on these lines. Therefore, T_0 corre sponds to the temperature where Δ G (T) = 0 at a given pressure, Thus, Ms-temperatures (Ms $^{\gamma\rightleftarrows\alpha'}$, Ms $^{\gamma\rightleftarrows\varepsilon'}$ and Ms $^{\varepsilon\rightleftarrows\alpha'}$) at which martensitic phase of ε' or α' of iron is first formed by $\gamma\rightarrow\alpha'$, $\gamma\rightarrow\varepsilon'$, $\varepsilon'\rightarrow\alpha'$ transformations was dertermined from the relationship between the driving force and free energy change in each transformation as shown in the equation (2). In the present work, 300, 100 and 200 cal/mol were used as the driving forces in the corresponding transformations on the basis of the results reported already[5)~10)26)27)] The results of the calculations are shown as the various lines of Ms $^{\gamma\rightarrow\alpha'}$, Ms $^{\gamma\rightarrow\varepsilon'}$ and Ms $^{\varepsilon\rightarrow\alpha'}$ in **Fig. 6.** Moreover, the relationship among these driving forces was assumed as follows.

$$\Delta G_v^{\gamma\rightarrow\alpha'} = \Delta G_v^{\gamma\rightarrow\varepsilon'} + \Delta G_v^{\varepsilon'\rightarrow\alpha'} \qquad (3)$$

The equation (3) means that the triple point exists in martensitic transformation and the free energy of the phase is not affected by the process of the transformation.

The calculated Ms $^{\gamma\rightarrow\alpha'}$ lines and Ms-temperatures measured at various pressures in Fe-0.2%C and Fe-0.42%C

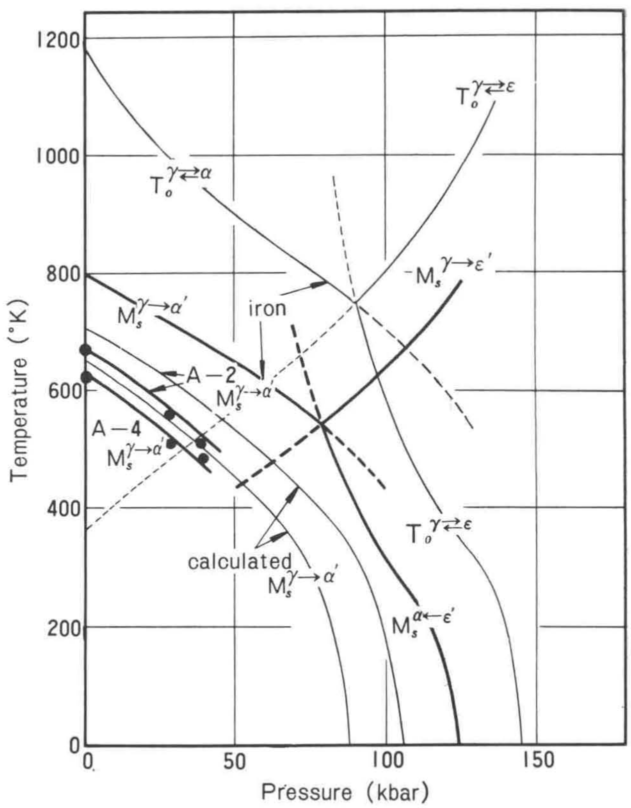

Fig. 5. Effect of Ms temperature on the microhardness of martensite formed in low alloys (Fe-0.3%C-X).

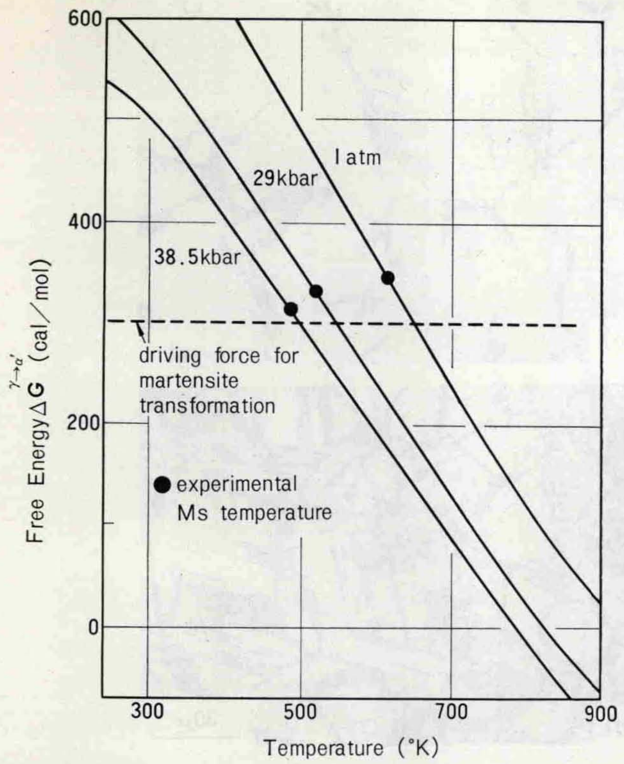

Fig. 6. P-T phase diagram of iron and effect of pressure on Ms-temperature of Fe-0.28%C (A-2) and Fe-0.42%C (A-4) alloys and iron.

alloys are indicated in **Fig. 6** in addition to the Ms lines of iron. A reasonable agreement between those is found in this figure. Moreover, $Ms^{\gamma\to\varepsilon'}$ lines on $\gamma\to\varepsilon'$ transformation of these alloys can be approximated by using those of iron. From the results mentioned above, 38.5 kbar is found to be the pressure close to the triple point at which

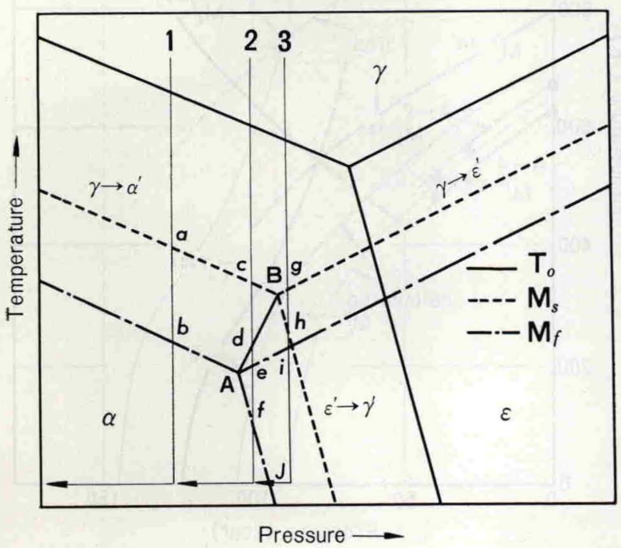

Fig. 7. A schematic illustration of P-T diagram on martensitic transformation in iron alloy.

three martensitic transformations occur simultaneously.

4.3. Change of martensite structure

It was attempted to explain the relation between the process of transformation and structure of martensite qualitatively, as shown in **Fig. 7** in which a P-T diagram with To, Ms and Mf of martensitic $\gamma\to\alpha'$, $\gamma\to\varepsilon'$ and $\varepsilon'-\alpha'$ transformations in an iron alloy is drawn schematically. If only the $\gamma\to\alpha'$ transformation at atmospheric pressure in the alloy occurs, the transformation takes a process of **1, 2** or **3** during cooling from γ phase under pressures. At the pressure of **1,** α' phase is primarily formed at $Ms^{\gamma\to\alpha'}$ point and then the volume fraction of α' phase increases with a decrease of temperature from Ms to Mf point (b) where the transformation is completed. In this case, the structural change from lath martensite to twin one was observed with an electron microscope and the change from packet structure to lenticular one was observed under an optical microscope. These phenomena may be as a result of pressurizing which might bring the depression of Ms-temperature and the same effect as that of the rapid cooling at atmospheric pressure. At the pressure of **2,** α' phase is primarily formed from γ phase at $Ms^{\gamma\to\alpha'}$ points (c) which is similar to that in the case of pressure **1.** Furthermore, when temperature decreases to point (d) across the AB line, which is connected between the two triple points of Ms and Mf, untransformed γ phase begins to transform to α' phase through ε' phase, and then at $Mf^{\gamma\to\varepsilon'}$ point (e) ε' and α' phases exist. Moreover, during cooling to $Mf^{\varepsilon'\to\alpha'}$ point (f), ε' phase transforms to α' phase. Consequently, it seems that the martensite structure as shown in **Photo. 7** could be observed at 41 kbar which might correspond to the pressure of **2.** In this case, the plate-like structure due to the $\gamma\to\varepsilon'\to\alpha'$ transformation was formed around the packet or lenticular structure which was primarily formed as a result of $\gamma\to\alpha'$ transformation. The easy formation of plate-like structure around the lenticular structure may be due to the instant increasing of pressure, caused by the $\gamma\to\alpha'$ transformation, at the boundary of α' phase. However, from the observation that only plate-like structure increased as the temperature decreased from Ms point as shown in **Photo. 8,** it is estimated that the pressure was not so high as 600 kg/mm^2 [28]. Under the pressure of **3,** during cooling from the γ phase, ε' phase forms primarily at $Ms^{\gamma\to\varepsilon'}$ point (g) and the ε' phase transforms to α' phase at $Ms^{\varepsilon'\to\alpha'}$ point (h). After further cooling, $\gamma\to\varepsilon'$ trans-