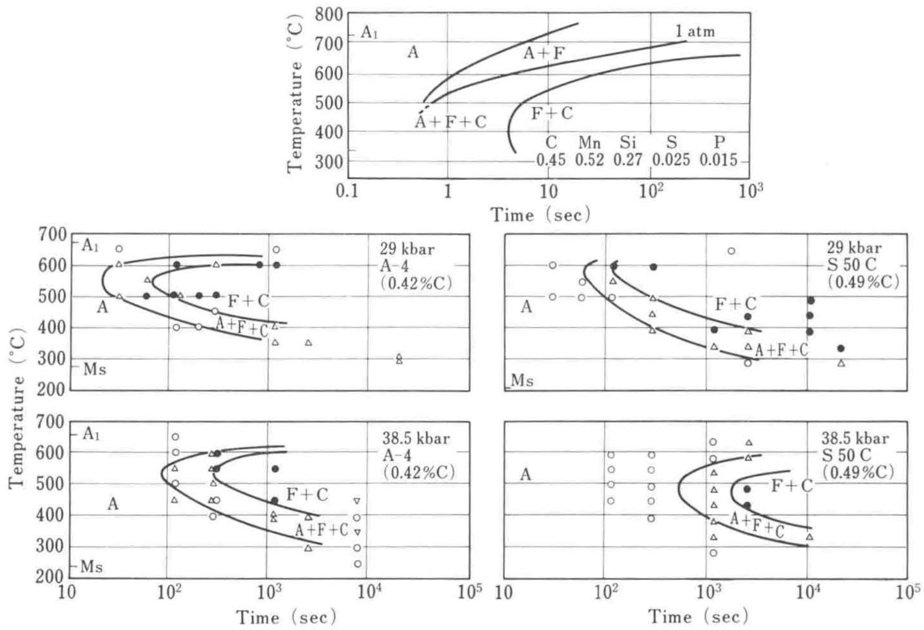

Fig. 3. TTT diagrams obtained in Fe-0.42%C alloy and 0.49%C commercial steel under high pressure. For comparison, a diagram[16] of 0.45%C steel at 1 atm is quoted at the top

hypo- to hypereutectoid accompanied with the increase of pressure from 1 atm to 29 or 38.5 kbar. The TTT diagrams obtained at 29 and 38.5 kbar on these materials are shown in Fig. 3, and at the same time, a diagram on a 0.45%C steel at 1 atm is also quoted[16] in this figure for reference. The diagrams under high pressure show only C-shaped curves similar to those in Fig. 2, and do not show any starting curve for the primary precipitation of carbide. The reason why these results were obtained can be explained as follows; although the carbon content in these specimens was chosen on the basis described above, as the quantity and size of the proeutectoid carbides precipitated under high pressure were too small and too fine, so that it was difficult to determine the position of the beginning of precipitation on the curve correctly.

When the incubation time at 500°C in the S50C steel transformed isothermally at high pressures is compared with that at 1 atm, it is noted that the former is about 200 times at 29 kbar and 1 000 times at 38.5 kbar longer than the latter. These values are larger than the one reported by Nilan[6] on a 0.44%C steel at 24 kbar. This fact is thought to be due to the differences in the examined pressure and the composition of specimen, especially in its impurities. Actually, the diagram of the high purity A-4 alloy at 38.5 kbar is in considerably good agreement with that of the Fe-0.41%C alloy at 42 kbar in Radcliffe's paper.[5] Consequently, if the differences in these conditions and additionally the procedure for applying high pressure are taken into consideration, the results obtained in this study can be asserted to be not so widely different from those which were reported hitherto.

The microstructures of the S50C steel transformed isothermally at a temperature higher than the nose are shown in Photo. 3. In these photographs, Photo. 3 (a) shows the proeutectoid ferrite formed at 700°C for 2 min at 1 atm. On the other hand, Photos. 3 (b) and (c) show the proeutectoid carbide precipitated at austenite grain boundary and the pearlite in a treatment at 650°C and 38.5 kbar for 1 hr, and it was confirmed that such hypereutectoid structure would be expected by pressurizing the specimen without increasing the carbon content, although it showed a hypoeutectoid structure originally at 1 atm.

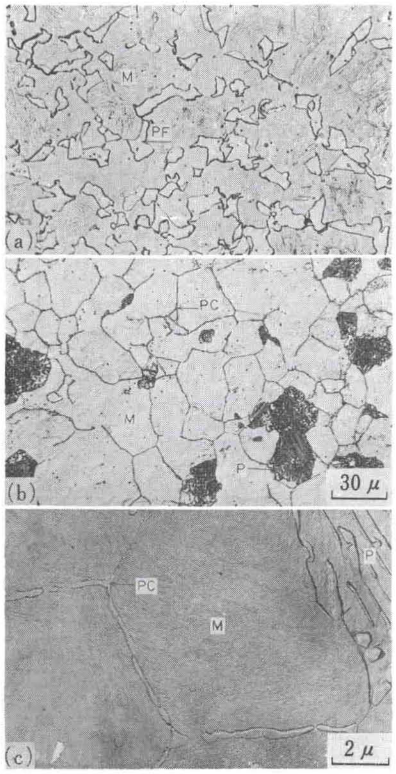

Photo. 3. Comparison of the transformation products formed in 0.49%C steel at 1 atm and 38.5 kbar
(a) Proeutectoid ferrite (PF) in martensite matrix (M); 1 atm, 700°C×2 min
(b), (c) Proeutectoid carbide (PC) and pearlite (P) in martensite matrix (M); 38.5 kbar, 650°C×1 hr

Photograph 4 shows the structures obtained in a temperature range below the nose. In Photo. 4 (a),

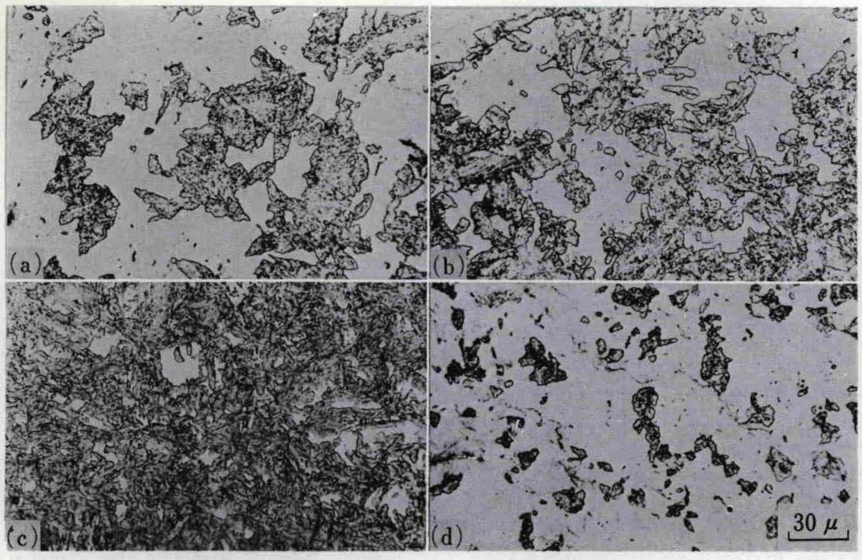

Photo. 4.
Microstructures observed in Fe–0.42%C alloy (a), (b), (c) and 0.49%C steel (d) treated isothermally under high pressure
(a) Aggregate; 29 kbar, 400°C×20 min
(b) Columnar bainite; 29 kbar, 350°C×20 min
(c) Aggregate; 38.5 kbar, 350°C×3 hr
(d) Aggregate; 29 kbar, 350°C×1 hr

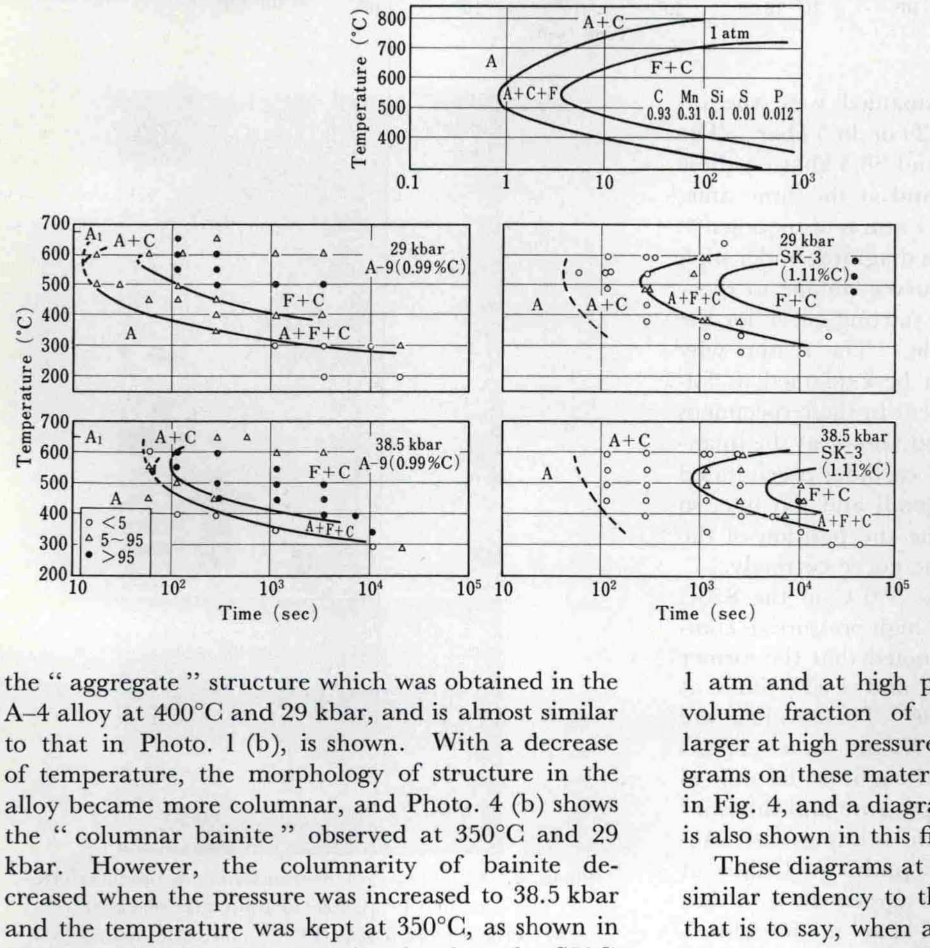

Fig. 4.
TTT diagrams obtained in Fe–0.99%C alloy and 1.11%C commercial steel under high pressure. For comparison, a diagram[17] of 0.93%C steel at 1 atm is quoted at the top

the " aggregate " structure which was obtained in the A–4 alloy at 400°C and 29 kbar, and is almost similar to that in Photo. 1 (b), is shown. With a decrease of temperature, the morphology of structure in the alloy became more columnar, and Photo. 4 (b) shows the " columnar bainite " observed at 350°C and 29 kbar. However, the columnarity of bainite decreased when the pressure was increased to 38.5 kbar and the temperature was kept at 350°C, as shown in Photo. 4 (c). On the other hand, when the S50C steel was examined at 350°C and 29 kbar, the observed structure was rather similar to aggregate than columnar as shown in Photo. 4 (d). Consequently, it was understood that the columnarity of bainitic structure depended on the temperature and the pressure at which the specimen had transformed, and also on the quantity of impurities in the materials.

3. Fe–*0.99*%C(*A–9*) *Alloy and SK3 Steel*

As these materials contain the corresponding carbon to obtain the hypereutectoid structure both at 1 atm and at high pressure, it is expected that the volume fraction of proeutectoid carbide must be larger at high pressure than at 1 atm. The TTT diagrams on these materials at high pressures are shown in Fig. 4, and a diagram on a 0.93%C steel at 1 atm is also shown in this figure for reference.[17]

These diagrams at high pressures have a essentially similar tendency to those shown in *III. 1* and *III. 2*, that is to say, when a diagram at 1 atm is compared with the others in Fig. 4, differences are recognized not only in the incubation time but also in the temperature range in which the carbide was formed. It is already known that the decomposition of austenite to carbide and ferrite accompanies with a decrease of volume. According to Kaufman,[10] the volume decrease of 0.42 cm^3 took place at 996°K as the result of the precipitation of 0.25 mol of Fe_3C from 0.75 mol of austenite in which 0.25 mol of carbon had been contained. This fact suggests that the Fe_3C which is having higher density than other phases is easier to be formed at high pressure. Actually, as can be seen