121. Temperature-composition Curve of the Layers in the Act of Deposition. — We may represent graphically on this same diagram the temperature-composition locus of still a third entity, the layers in the act of depositing at any given instant, as distinguished from the average of the mass already frozen at such instant. Thus, starting as before with composition q'', the first deposited layer has, as we have seen, composition p; the last particle of mother-metal to freeze has composition s; but the last layer to freeze must necessarily have the composition of the last particle of the mother-metal to freeze, since it is the latter which in freezing turns into the former. Hence the composition of the last frozen layer is s; and the composition of the successive layers to freeze out will lie along the line ps, though as to the shape of this line nothing is here said. ps evidently corresponds to the part BC of Fig. 30, p. 71.

Note here a radical difference between these present curves and the other temperature-composition curves AB, CB, Aa, Cc and aBc. For whereas each of these latter five applies to a whole series of initial compositions, the curves for each of which are simply individual fragments of these five curves; the curve for the layers in the act of freezing is a different one for each initial composition.

122. The Same Curve for a Eutectiferous Alloy. — Taking now the case of an alloy so rich in metal G as to be eutectiferous, say with initial composition n'', the first layer to freeze will as before have composition n'. The last layer to freeze will in this case be of eutectic composition B. But the temperature-composition locus should not be a simple one, nlB, as in case of our non-eutectiferous alloy q. With falling temperature the composition should indeed slide along $n'B$, but on meeting the saturation-point curve Daa' at l, further enrichment of the depositing layers should cease, for the reason that they have now become saturated with metal G. (See § 66, p. 73.) Henceforth their composition should simply be that of saturation, *i. e.*, with falling temperature it should slide along la until it reaches a, simultaneously with the arrival of the mother-metal at eutectic composition and freezing-point B. But that which henceforth freezes is simply the eutectic; so that the locus of the temperature and composition for the layers in the act of freezing is (1) from n' to l and (2) from l to a; (3) it then leaps from a to B without

traveling along aB progressively. The progress from n' through l to a is per gradum, that from a to B is per saltum. This represents the abrupt demarcation of the eutectic which we find under the microscope.

123. Correspondence between the Cooling Curve and the Temperature-composition Curve of the Freezing Layers. — Turning now to Fig. 31, p. 71, for a given initial composition n'' the correspondence between it and Fig. 49 is as follows:

	FIG. 31	FIG. 49
Excess-freezing period		
Subsaturation division	BB'	$n'l$
Saturation division	$B'C$	la
Eutectic-freezing period	CD	B

124. No Gap in the Saturation-point Curve. — From the fact that between the lower boundary of the molten region of the freezing-point curve, ABC, Fig. 50, and the upper boundary, $AaBcC$, of the frozen region there is a pair of gaps, the triangles AaB and CcB, it might at first sight be thought that these triangles were a sort of no-man's land; that they belong neither to the molten nor to the solid state; hence that no alloys either molten or solid are really represented by them; hence, finally, that the saturation-point curves for the solid state should run only from D to a and from E to c, and that the intercepts aa' and cc' have no true existence and should be struck out, on the ground that it is unfair and misleading to draw curves representing the properties of non-existent substances.

But this is fallacious. The fallacy comes from ignoring the fact that $AaBcC$ is the boundary of the solid region only on the assumption that that region has become homogeneous through diffusion. But during diffusion alloys in these triangles come temporarily into existence, and these ephemeral alloys have naturally a definite solvent power, just as much as if they were permanent. Hence we are quite justified in drawing the parts aa' and cc' through these triangles. The fallacy then is in supposing that these alloys, because only ephemeral, do not exist.

That they do exist may be made clear by refreshing our memory as to what happens in the freezing of an alloy say of composition q'', Fig. 49. Let us assume that only the last smallest particle of mother-metal remains unfrozen, and that equilibrium

has been established throughout. We have seen that, in this case, the composition of the already frozen part is substantially *r*, while that of the molten mother-metal is *s*. Let us now suppose that, through further removal of heat from this system, this last particle of mother-metal is deposited with composition *s*, upon the previously frozen part with composition *r*. Immediately the excess of metal *G* above ratio *r* in this last deposited layer begins diffusing back into the previously frozen layers, and continues (temperature and time permitting) until this flake like the rest of the mass reaches composition *r*. Now between the instant when this flake was deposited as *s* and this later time when it
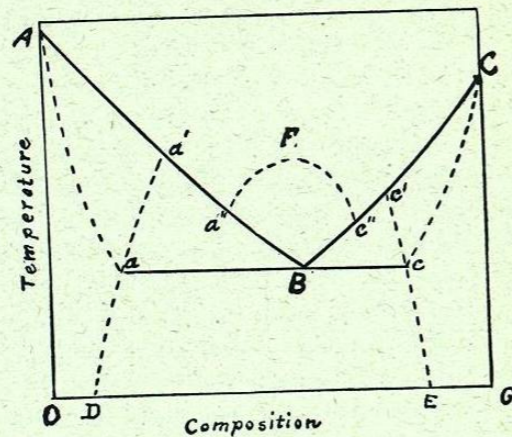

Fig. 50. Freezing-point and Saturation-point Curves.

reaches composition *r* through diffusion, it will have every composition intermediate between *s* and *r*. And in the same way every other point in the triangles *AaB* and *CcB* can be shown to have a real existence, even if a brief one.

Even the triangles *aa'B* and *cc'B* have a real existence. Thus, again assuming that equilibrium has been established, the last particle or flake to freeze from a molten alloy initially of composition *t''* (Fig. 49) will have composition *l'*. When this flake freezes, it will split up into a flakelet of a saturated solid solution of *G* in *H*, and another flakelet of a saturated solid solution of *H* in *G*, simply because it lies within the saturation-point curve. (§ 108, p. 125.) (Note this distinction between this last deposited

flake as a whole, and the twin flakelets, of which it is composed, one a solid solution of *G* in *H* and the other a solid solution of *H* in *G*.) Let us call these flakelets *G* and *H*. As the earlier frozen part with which these flakelets are in contact is unsaturated with metal *G* (composition *t*), part of the metal *G* in the flakelet *H* will begin diffusing into this older part, shifting the composition of flakelet *H* to the left, and thus leaving it unsaturated with *G*. But we saw in § 108, p. 125, that any alloy within the saturation-point curve must (for equilibrium) consist of distinct particles of each metal saturated with the other. The fact that our flakelet *H* is unsaturated with metal *G* leaves it and its twin flakelet of *H*-bearing *G* out of equilibrium, which will reëstablish itself by a readjustment of the *G* and *H* in these two flakelets into two new ones each saturated. The flakelet *G* will be smaller than before, in accordance with this diffusion of *G* into the older layers that has already occurred.

But the process which led to the first transfer of metal *G* from our flake of composition *l'* into the older layers will continue, and with it the composition of the flake as a whole will shift to the left. But this flake will continue to consist of two distinct flakelets until its composition crosses *aa'* at *l*, when the last particle of *H*-bearing *G* will vanish and we have only our remaining flakelet of *G*-bearing *H*. At *l* it will be saturated with *G*; as its *G* continues diffusing into the older layers and the composition of our flakelet travels towards *t*, it becomes unsaturated; with further diffusion of *G* it gradually approaches and at last reaches composition *t* at the very time when the older layers reach that composition, by the complete equalization of the percentage of metal *G* throughout the different layers.* Thus every point between *l'* and *l* has a temporary existence; and so, by like reasoning, has every other point in the triangles *a'aB* and *c'cB*.

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* Through a like fallacy it might well be thought that the saturation division *B'C* of the cooling curve, Fig. 31, had no true existence, because, according to the temperature-composition curves of the frozen layers, those layers reach saturation only at the moment when the eutectic begins to freeze.

But, like the fallacy already discussed in this section, this comes from confusing the composition of the frozen layers, after they have become homogeneous through diffusion, with the composition of the layers