Arrangement of Towers. In separating a series of products from a charge stock, three main tower arrangements are employed. Heavy-oil stocks, such as crude oil, are usually separated in a single tower, as indicated in Fig. 7-7. In such a system the feed enters somewhat low in the column, the lowest-boiling product issues from the top as a vapor, and the heavier distilled products are withdrawn from the side of the column. The small towerlike equipment shown in the center of Fig. 7-7 is not a fractionating tower. It is a series of three steam strippers set one above another. The system of Fig. 7-7 is unsatisfactory for producing highly pure products such as pure hydrocarbons because the lighter products pass the withdrawal trays of the heavier products as they proceed from the feed plate to the top. For precise separations a series of towers (one tower less than the number of products) as shown in Fig. 7-2*a* or *b* is often employed. In Fig. 7-2*a* the lowest boiling product is vaporized in tower No. 1 by reboiler heat at the bottom of tower No. 1, and successively higher and higher boiling materials are removed in the remaining six towers. The feed is pumped from tower to tower, each tower is cooled by refluxing a part of the overhead product into the top of the tower, and the bottom of each tower is heated by steam or a hot circulating oil by means of reboilers. Successive fractional condensation is practiced in Fig. 7-2*b*. Here an almost completely vaporized stock is cooled in tower No. 1 to condense the highest-boiling product, and successively lower-boiling products are condensed in the remaining six towers. The novel but little used Brugma[1] arrangement of towers shown in Fig. 7-2*c* employs only three towers, but the total length of the three towers is about the same as the length of the seven towers in Fig. 7-2*a* and *b*. Obviously, many combinations of these tower arrangements are possible, as in Fig. 7-8.

More material can be vaporized (at a given temperature) by a single flash vaporization than by several flashes, and hence the use of a single multidraw tower (Fig. 7-7) is better in this respect than the series arrangements of Fig. 7-2*a* and *b*. Refer to Chap. 15 for a mathematical discussion of methods of vaporization.

Steam Stripping. Steam is used to raise the flash point of most of the heavy-oil products withdrawn from the side of multidraw towers and for

[1] *Ref. Nat. Gaso. Mfr.*, September, 1941, p. 86.

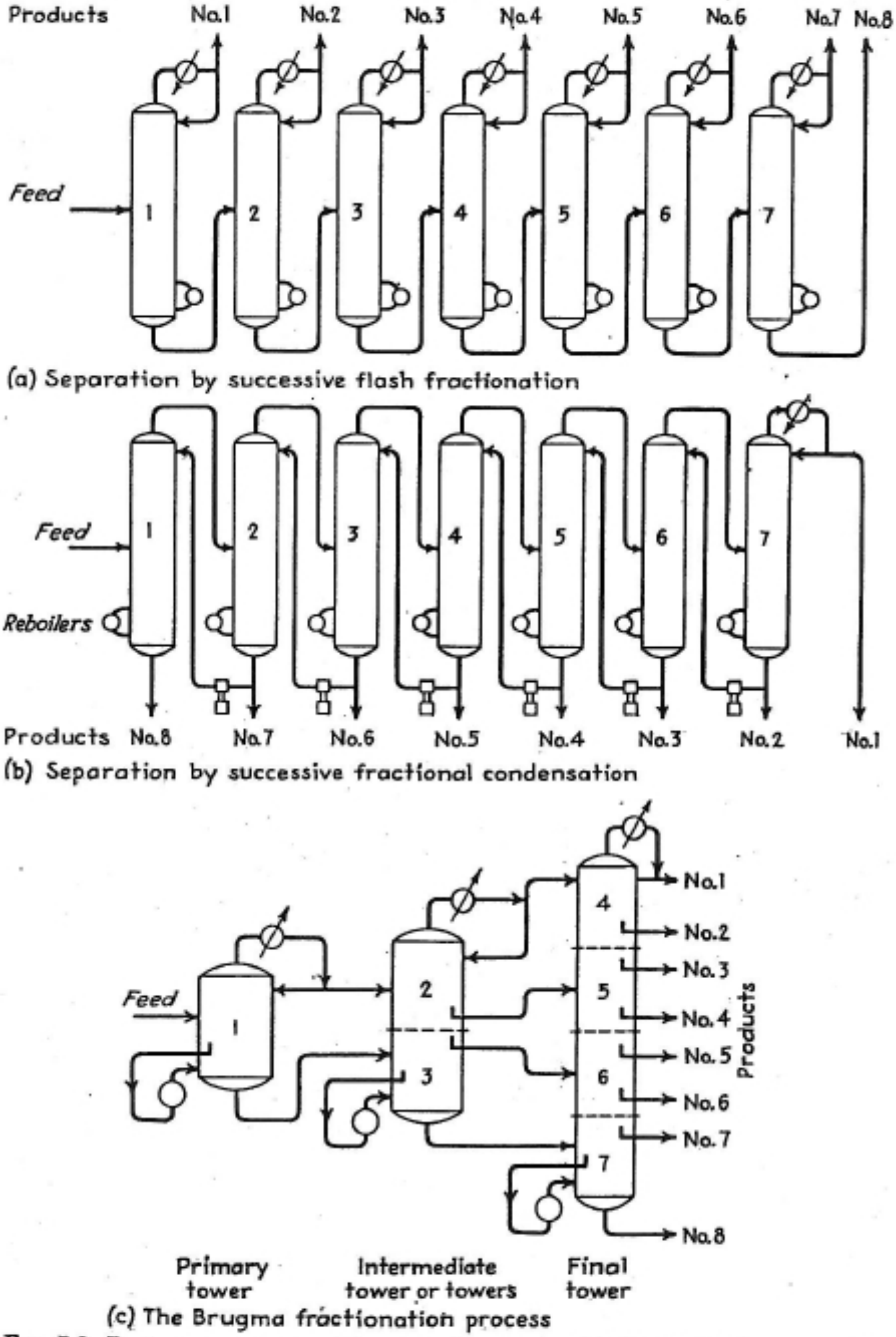

FIG. 7-2. Basic arrangements of fractionating towers. (*a*) Separation by successive flash fractionation; (*b*) separation by successive fractional condensation; and (*c*) the Brugma fractionation process.

the bottoms product of heavy-oil towers. The hot oil is contacted with the steam in a so-called "stripping tower" which may be a packed tower (up to 20 in. diameter) but usually consists of bubble trays or side-to-side pans. The use of four bubble trays (about seven side-to-side pans) is common, but in the extreme ten plates have been used. If as much as 6 to 10 per cent of low-boiling material must be removed by stripping, it is usually more economical to adjust the composition of the product in the fractionating tower than to steam-strip.

The approximate relation between flash point and (0 to 10 per cent) boiling range is given in Eq. (4-6*a*). With this relationship it is possible to estimate the amount of material that should be removed by stripping in order to obtain a satisfactory flash point. Figures 7-3 and 7-4 indicate the approximate amounts of steam required in stripping naphtha, kerosene, distillate, gas oil, topped crude oil, and similar products.[2] Figure 4-49 indicates the wide range of kerosenes (or similar products) that can be produced by adjustment of the fractionating tower and degree of stripping. The dotted lines (Fig. 7-4) are examples of the effect of infinite plates on gas oil and on topped crude oil. Stocks such as topped crude oil (which are wide-boiling or have been disengaged from a wide-boiling material (such as crude oil) require large amounts of stripping steam.

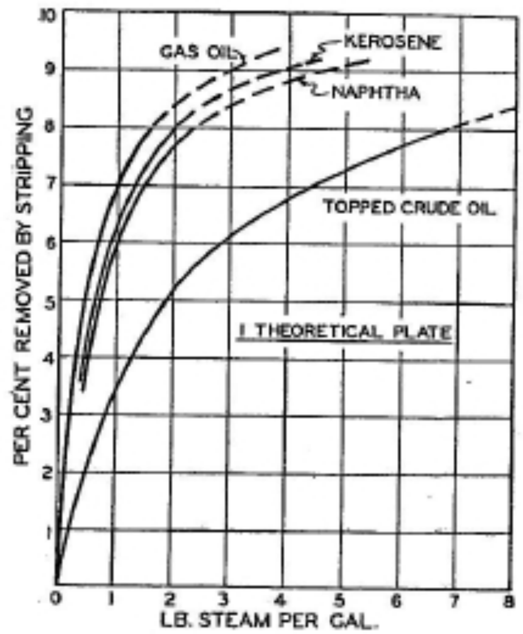

FIG. 7-3. Approximate steam required to strip when using only a bath of liquid, i.e., only one theoretical plate.

Example 7-1. Amount of Stripping Steam. An unstripped kerosene has an initial boiling point of 200°F, a 5 per cent point of 310°F, and a 10 per cent point of 355°F, which is an average temperature of about 288°F. Its flash point is about 90°F.

According to Eq. (4-6*a*), a 0 to 10 per cent front boiling range of 344°F will be required to obtain a flash point of 120°F. Six or seven per cent of the material must be removed to produce a 344°F front end; and, according to Figs. 7-3 and 7-4,

No. of plates	*Lb steam per gal*
1 (Fig. 7-3)	1.0
4 (Fig. 7-4)	0.45
10 (Reference 2)	0.40

[2] Nelson, W. L., *Oil Gas J.*, Mar. 2, 1944, p. 72; July 21, 1945, p. 128; and May 12, 1945, p. 51.