The method is simple but special cases arise where engineering judgment must be exercised. Attention is called to the difference in design between risers Nos. 3 and 4. On the cold water riser No. 3, there are 6 water closets, 4 urinals and 4 lavatories with a combined fixture value of 73.0 per floor. As the time consumed in flushing is small the diversity factor will be the same as for other risers of the system and the regular method may be followed. On the cold water riser No. 4, however, the 12th, 13th, 14th and the 18th to the 22nd floors have 2 water closets, 2 urinals and 1 lavatory with a fixture value of 25.8 per floor and the 15th, 16th and 17th floors each have 6 rain head showers, 6 needle showers, 4 water closets, 4 urinals and 3 lavatories. The water closets, urinals and lavatories would have the usual diversity of use, but if it is suspected that the showers will have periods when they will be crowded and in almost constant use it will be necessary to make the branch almost full size and, of course, the riser correspondingly larger. The factor values that will follow the usual diversity are:

4 W. C.	= 38.8
4 Urinals	= 10.8
3 Lavatories	= 3.0
Total	52.6

The unusual factors are:

6 Rain head showers	= 6.0
6 Needle showers	= 33.0
Total	39.0

Since the showers must be given an almost full supply, the pipe size to supply them must be taken from Table 2 which indicates a pipe slightly larger than a 2-in. pipe. If the size had been taken from Table 3, a 1½-in. pipe would have been indicated. Adopting the 2-in. pipe instead of the 1½-in., the value to be used in the diversity table must be increased by the difference in the carrying capacity of the two pipes as taken from Table 2. This is:

$$32.0 - 15.3 = 16.7 \text{ or, roughly, } 17.0$$

The fixture value for the floor should then be taken as:

$$52.6 + 39.0 + 17.0 = 108.6$$

and according to Table 3, the diversity table, a 2½-in. branch pipe should be used. The fixture value of 108.6 is then added to size the riser for the 16th and 17th floors as shown in Fig. 2. A similar increase is made for the hot water riser.

SIZING MAINS AND HEADERS

To size the headers for either the hot or cold water, it is only necessary to total the values for all the risers that they supply and take the pipe size from Table 3 as was done in sizing the risers themselves. Thus at *A* (Fig. 2) the size is found to be a 3½-in. pipe, and at *B* the fixture value falls close to the dividing line between the 4-in. and 5-in. pipes. If the roof tank is at a high elevation giving considerable pressure the 4-in. pipe

might be sufficient. If there is but a small initial pressure it might be advisable to use the larger size.

To determine the loss of pressure that may occur at this point where the supply for 3 risers to 11 floors each is flowing, consider this point as the 33rd floor, and by the use of Formula 1, the percentage of flow at some peak moment is found to be:

$$\frac{224}{33 + 2} + 10 = 17 \text{ per cent}$$

of the actual total fixtures supplied. The total number of fixture equivalents at this point is 1300 and a flow may therefore be expected at some time sufficient to supply:

$0.17 \times 1300 = 221$ fixtures, which at 5 gpm per fixture amounts to:

$$5 \times 221 = 1105 \text{ gpm.}$$

Table 4 gives the amount of water in gallons per minute which will flow through various pipes for various pressure drops. By referring to this table it is found that the friction loss for 1105 gpm through a 4-in. pipe is nearly 50 lb per square inch per 100 linear feet of pipe while through a 5-in. pipe it is approximately only 15 lb per square inch. It will therefore be advisable to adopt the 5-in. size. This method may be conveniently used to design up-feed systems feeding from city pressures. (See Example 3).

In the drop line from the tank to the hot water heater and the riser from the heater to the distributing header on the 21st floor there are approximately 200 linear feet of pipe. If the friction loss through this length of pipe is too great, there will be too large a difference in the pressures at the cold and hot water fixtures on the different floors. All the hot water for the 8 risers feeding 11 floors each, or 88 floors in all, and supplying 1043 fixtures (½-in.) must flow through it. Owing to the diversity factor, the maximum expected flow at some time will be:

$$1043 \text{ fix.} \times 5 \text{ gal} \times \left(\frac{224}{88 + 2} + 10\right) \text{ per cent} = 652 \text{ gpm}$$

From Table 4, it is found that this amount will create a pressure drop of approximately 5 lb per square inch per 100 ft of 5-in. pipe.

Attention is called to the fact that the headers on the 21st floor are made to supply the 22nd floor fixtures by means of up-feed branches. Similarly, the headers on the 10th floor feed the fixtures on the 11th. This provides an outlet for any air that may be trapped in the piping. Again, the hot water risers are connected to a return header for gravity circulation. These are of ¾-in. pipe and there is no necessity for a larger connection. The headers are then sized for the number of risers they are to accommodate as taken from Table 2. At each ¾-in. connection to the header, however, it is well to install a lock-shield gate valve which may be adjusted to equalize the circulation.

SIZING OF BRANCH PIPES

Most valves will deliver the quantity stated in Table 1 with a pressure of 6 lb per square inch at the valve. This does not mean the static pres-