use. The assumed percentage of simultaneous use varies greatly among designers of water supply systems. Even a precise mathematical calculation as to its value must be based on an assumption of the probable number of times the fixture is used per unit of time. To arrive at a safe practical value of the probability an analysis of the composite layout was made which shows the flow following closely along the curve shown in Fig. 1, the probability being almost 100 per cent at the last floor supplied and diminishing to a minimum of 10 per cent.

The following equation may be written to fit the curve of Fig. 1:

$$P = \frac{224}{F + 2} + 10 \qquad (1)$$

where

P = per cent of simultaneous use (expressed as a whole number).
F = the number of floors being supplied.

Example 1. For a riser supplying two bath rooms on each floor, each bath room fitted with one 1¼-in. flushometer connection, one ¾-in. bath and one ½-in. lavatory connection, the rate of flow for each room if all fixtures were opened simultaneously as taken from Table 1 would be 68 gpm, and for each floor, 136 gpm. For the fifth floor the amount will be 5 × 136 = 680 gpm. The probable simultaneous use at the fifth floor, however, is only:

$$\frac{224}{5 + 2} + 10 = 42 \text{ per cent}$$

and the riser must therefore be designed to carry

$$0.42 \times 680 \text{ gpm} = 286 \text{ gpm}$$

at whatever friction loss the conditions will allow. (See Example 2).

At the 10th floor supplied, the amount flowing at some one time may be expected to reach:

$$10 \times 136 \times \left(\frac{224}{10 + 2} + 10\right) \text{ per cent} = 394 \text{ gpm}$$

In a 10-story building with 22 similar risers the main would be required to supply:

$$\frac{224}{(10 \times 22) + 2} + 10 = 11 \text{ per cent of the total fixture supply.}$$

Formula 1 is based on the number of floors in the building and therefore only applies when the distribution of fixtures on each floor is equal, or nearly equal. Where the fixtures are unequally distributed a percentage of maximum simultaneous use must be estimated for the fixtures on each level and on each portion of the riser, this percentage grading from 100 per cent for the first two fixtures on the end of each branch down to a minimum of about 25 per cent where 500 or more fixtures are installed. The number of gallons per minute used by all the fixtures supplied by a branch or riser at any particular point multiplied by this estimated percentage of mixximum use will then give the maximum probable number of gallons per minute passing through the pipe at this point, and the pipe may then be sized on the basis of the friction drop allowable for the conditions involved. Special percentages of maximum simultaneous use must be developed for gang showers, batteries of lavatories for industrial work, and other groups of fixtures where an unusual maximum demand may exist during certain specified hours.

TABLE 3. NUMBER OF ½-IN. PIPES ACCOMMODATED BY A SINGLE PIPE IN THE AVERAGE TYPE BUILDING WITH ALLOWANCE FOR SIMULTANEOUS USE

Pipe Diameter (In.)	Number of ½ In. Pipes	Pipe Diameter (In.)	Number of ½ In. Pipes
1	3 to 5	3½	431 to 700
1¼	6 to 11	4	701 to 1200
1½	12 to 44	5	1201 to 2400
2	45 to 100	6	2401 to 5000
2½	101 to 220	8	5000 up
3	221 to 430		

Due to a lack of variety in commercial sizes it is not possible to change the size of the riser at each floor. When an increased size is first used the friction loss per unit of length must of necessity be less than the predetermined amount but will increase as the floors are added until it is approximately an equal amount in excess of the loss desired when the size must again be increased. The average loss through the section will be near that desired.

To facilitate the design, the equivalent number of smaller pipe supplied by each large pipe at its location in the composite layout was determined as shown in Table 3. For convenience these values are all referred to the equivalent in ½ in. pipes as specified in Table 2. It should be noted that Table 3 allows for the diversity factor or per cent of simultaneous use.

Example 2. Fig. 2 shows the piping layout of the upper half of a 22-story structure which is typical of office, hotel, club and apartment risers. Taking riser No. 1, the outlets on each floor consist of two 1¼-in. flushometer valve connections, two ¾-in. connections for bath, and two ½-in. connections for the lavatories.

The total factor value for the cold water riser as taken from Table 2 is:

$$\begin{aligned} 2 \times 9.7 &= 19.4 \text{ for flushometers} \\ 2 \times 2.7 &= 5.4 \text{ for baths} \\ 2 \times 1 &= 2.0 \text{ for lavatories} \end{aligned}$$

Total for each floor 26.8 pipe equivalents

Thus with the first floor supplied (the 12th story in this case) the riser must supply

TABLE 4. AMOUNT OF WATER IN GALLONS PER MINUTE WHICH WILL FLOW THROUGH VARIOUS SIZED PIPES FOR VARIOUS PRESSURE DROPS

Friction Pressure Drop Pounds per Square Inch per 100-ft. Run	Pipe Sizes in Inches									
	¾	1	1¼	1½	2	2½	3	3½	4	5
5	5.4	11	19	30	62	109	171	252	353	610
7	6.4	13	23	36	74	129	203	298	418	720
10	7.6	15	27	43	88	154	242	357	499	862
20	10.8	22	38	61	125	218	343	504	706	1221
30	13.2	27	47	76	153	267	420	618	864	1500
40	15.0	31	54	86	176	308	485	714	998	1725
50	17.0	35	60	96	197	345	542	800	1115	1930
75	21.0	43	74	117	242	423	665	978	1365	2370
100	24.0	49	85	136	278	485	769	1130	1578	
125	27.0	55	96	152	311	544	858	1260	1765	
150	30.0	60	105	166	341	598	939	1380	1930	