the tile did not aid in stiffening the column, then the radius of gyration of that column should be 1/120 of that length; or, 40 ft. being 480 in., there would be a radius of gyration of 4 in., and the engineer would select a form of column where he would have a radius of gyration of 4 in. The form is a matter of preference. Probably in a case like that the average engineer would select a box-shaped column, as it is easier and cheaper to get a radius of 4 in. with the box shape by using channels and cover plates.

J. Norman Jensen: It might be advisable for me to review some of the features of the ordinance in regard to columns. As you probably know, the ordinance formula for the allowable stress is $16{,}000 - 70\frac{l}{r}$, and if the column is filled with concrete, and also encased with concrete, so that there is at least 3 in. of concrete outside of the metal, there is permitted an allowable stress of $18{,}000 - 70\frac{l}{r}$, but not to exceed 16,000 lb. In the first formula referred to, the limiting stress is 14,000 lb. These are the highest stresses that can be used, and the limiting length of the compression member is 120 times the least radius of gyration. You will find, if you want to use an I-beam column, as is sometimes advisable, say a 6-in. I-beam, you could not use a length more than 7 ft. 2 in., and if you had an ordinary ceiling height of 10 ft., or a little more, you would have to use a 15-in. I-beam, 42 lb. per ft. This 15-in., 42-lb. I-beam would be insisted on, even for the top floor of a building where there is only a light roof load, because we have only the ordinance to go by, and that is the requirement of the ordinance. In order to meet the condition for slender columns, the Lally and the Acme columns have grown into use under the protecting wings of the ordinance. Where you would have to use, say, a 15-in. I-beam, 42-lb., you could use a Lally column or an Acme column 4½ in. in diameter, and satisfy the requirement as to length. Probably most of you know that these columns are merely pipes filled with concrete under pressure. In the city of Chicago there are two types—the older form called the Lally column, and another form called the Acme column—a recent competitor. While, of course, we cannot show any preference, we find that the details of the Acme column are considerably better.

The reason for bringing up this topic of light compression members, and the cause of this discussion about the limiting length of compression members, is that in apartment-house work in particular we want a column to fit inside of a partition. A 15-in. 42-lb. I-beam will not go inside of that partition, and so the architect and the engineer are compelled to use these round forms of columns, in order to comply with the rule in regard to limit of length. We would like to see the ordinance changed. We would like to see the limiting length increased from 120 to 150 times the least radius of gyration. This would allow the use of I-beam columns which are now practically excluded in buildings. The average round pipe column is of rather flimsy construction. There is no stiffness or rigidity about it. The use of an I-beam column for light loads will give something that is fairly stiff, and will be a section to which an I-beam can be riveted or bolted.

Tests at the Watertown arsenal, and other places, show that the radius of gyration has practically nothing to do with the strength of the column. The recent tests at Watertown arsenal show, for the lengths tested (from 25 to 175 times the least radius of gyration), that there was practically no difference in the strength. The one at 25 was just about as strong as the one at 175 times the least radius of gyration. So it seems that we are placing altogether too much emphasis on the theoretical considerations, and that we must come back to common-sense ideas and realize that in a compression member we want a good sturdy member, a member all of whose parts will work together, and not a highly theoretical member where the metal is in thin sections widely spread.

I spoke of the building ordinance and my hope that it would be changed to allow the use of I-beam columns in buildings. If such a change were made I would also suggest that the wording of the limiting length of cast-iron columns be changed. At present it reads: "The limiting length of a cast-iron compression member shall not be more than 70 times the least radius of gyration." The average layman and the person who has many other things to think about does not want to figure out the "70 times the least radius of gyration." The way that rule was obtained was this: They took the old rule of thumb of limitation of the length of a cast-iron column to 24 times its least diameter and translated it into 70 times the radius of gyration.

I do not know particularly what columns are referred to as freak columns. Sometimes we run across water-tanks carrying very heavy loads with supporting columns of single angle sections. Of course, theoretically that would seem to be all right, but it does not always look right. Outside of that I do not know of any particular instance just now.

Mr. Vanderlip: May I ask a question? Mr. Jensen remarked about the radius of gyration not having much to do with the strength; this made me think of the form of column that is used in a long boom—some of these modern long booms for derricks, 50 or 60 ft. long. They make those out of four angles, and near the ends where the blocks and pulleys are fixed they come down to possibly 8 in., back to back in both directions. Then as they go toward the centre they bow them out so that they are perhaps 16 or 18 in. wide. Would that not seem to indicate that the radius of gyration is a very important thing in there. The farther out they bow, the larger becomes the radius of gyration to take care of the bending tendency of the column.

Mr. Jensen: The point I wanted to bring out is that theoretical considerations lay large stress on the radius of gyration, but actual tests show it does not make any difference, as is shown at the Watertown arsenal—I am referring to this in particular. They took a certain type of column, and varied the ratio of $\frac{l}{r}$ from 25 to 175., and they found, so far as the load-carrying capacity of the column was concerned, that the ratio of $\frac{l}{r}$ seemed to make no difference; a long column would carry just as much as a short one. Some recent tests at the University of Illinois indicate that this radius of gyration—a thing that has troubled us ever since our student days—really has no right to trouble us. It has not much to do with the strength of the column. We have to make some allowance for it, in a way, but we should not lay as much stress on it as we do.

These tests also bring out another fact. According to the formulae for long columns, we ought to get the higher stress in the middle of the column. When the column is tested, that highest stress is not necessarily at the middle. It may be there or somewhere else.

I do not wish to discredit theoretical considerations, by any means, but to me it is more important to be guided in all these things by actual tests, and if these tests show that the radius of gyration has not much to do with the strength, we ought to throw overboard the radius of gyration.

Mr. Davidson: Mr. Jensen brought out one point that has troubled me somewhat, and that is how to make rigid