connection between a floor beam and a Lally or Acme column. He also brought out in his remarks the advisability of using the I-beam. With an I-beam with floor beams riveted to it, there is rigidity to a building. In the other case there is a little steel or iron pipe filled with concrete, set up on a little cap, with no rigidity to it at all.

H. J. Burt: With reference to using I-beams for columns and also other light members, where the load is small in comparison to the section that is required on account of the rule limiting the value of $\frac{l}{r}$, I have resorted to this expedient: I have figured the radius of gyration of only the outstanding metal; that is, the flange of the I-beam. That permits one to go to a longer length for a good sized member and seems to me to be altogether permissible, provided there is enough metal in the flange to carry the load specified.

W. L. Cowles: It seems there can be no question about the cylindrical section. Probably the strongest—it must be the strongest—is the pipe section, and evidently such a form of section has been used for building construction recently, but I should imagine that it might be quite difficult to make satisfactory connections. I am not familiar with the dimensions and what the connections may be. I recall that pipe sections—in fact, actual gas pipes—were used quite extensively by the Brown Hoisting Machinery Company some years ago. The sections were prepared by putting them in the blacksmith shop and straightening out or flattening the ends. They were used in a riveted connection, and for compression members so far as they were available; also for the posts of bridges—the chords, however, being made of channels—and for lateral struts.

I have never seen this method of construction used anywhere else, and in many places it might be considered a difficult or uneconomical one as to shop work, but the Brown Company was equipped for that kind of work, and the results seemed to be very good. The pipe section certainly proved economical in construction and served the purpose very well.

I do not know whether the Brown Company is still using that section or not, but if these pipes can be utilized economically they will naturally make the best section for the purpose.

Mr. Horton: It seems to me that the necessary thing to do in this matter of light column work is to take off the limitation as to radii length of the member. If there is any reason why the limitation should be 120, it has not been disclosed—only the mere fact that is happens there. The tests show 200 radii lengths doing just as good work essentially as 100. For many years I have said that a circular column, if we could make the connection rigid, is the ideal thing as far as cost and everything else is concerned, the difficulty being in the connections.

C. S. Pillsbury: Two small channels make a good section for light horizontal struts with no particular load, such as struts in water towers. In such a member the channels have their webs vertical and are laced horizontally. This design seems to work out very well as regards connections and is a fairly stiff and economical section. I have also seen the box shape, made of four angles with lacing on the four sides, used for very long horizontal struts. The difficulties with this last section seem to be that the lacing is too large a portion of the total weight of the section and that the shop work cost runs up considerably.

The fact brought out in regard to large columns—that they failed by wrinkling and not by flexure—is a most important point which is not always given the consideration that it merits. If composite members fail by wrinkling of the parts at 65% of the load that a pipe or **H** section will stand, then 35% of the maximum efficiency is lost. By spacing the rivets closer or by changing the proportion of the different parts, it may be possible to make built-up members approach nearer the strength of a solid section of equivalent area. Mr. Horton suggests that a large number of tests be made of small-sized members with variations in the relative sizes of the flange and web elements, and in the numbers and sizes of rivets. It might then be possible, from the results obtained, to recover some of the 35% lost efficiency.

Olin H. Basquin: In regard to pipe sections, I recollect that tests were made at the Watertown arsenal not long ago, perhaps within three or four years, in which Mr. Howard showed that pipe sections of moderate lengths fail practically always at their elastic limits when tested as columns. He also showed the same thing for these **H** sections, the form used by the Bethlehem Steel Company. These sections were used with square ends and were loaded very carefully. One would not expect to get such a result in actual practice because they could not be loaded as carefully in a structure as they were in the laboratory. That is one difficulty with all tests that have been made on columns, because the load which the column will stand depends very largely upon the care used in loading it, and the degree of accuracy used in getting that load at the centre of the column section.

The theory of columns is generally thought to be in a very unsatisfactory condition, but this is due to the fact that people do not pay attention to the theory that is already fairly well developed. About thirty years ago Professor S. W. Robinson, of the Ohio State University, published a paper on the strength of wrought iron bridge members, and that paper has been republished in No. 60 of Van Nostrand's Science Series. In that he gives the correct formula for maximum stress in a column, which is based on the same assumptions that are ordinarily used in the beam theory. This formula was rediscovered by Professor Marston, now of the Iowa State College, then a student at the University of Wisconsin, and was published in the Proceedings of the American Society of Civil Engineers, in connection with a paper by Dean Johnson, but Dean Johnson warned the public that this was a very dangerous theory to use in practice —for just what reason I do not know. This theory has crept into the German text-books and has been used there for a long time, but you will find it in a rather subordinate position in the better American text-books of the present time.

This theory depends upon the load on the column being a little out of centre; that is to say, it is the theory of eccentrically loaded columns and it is the true theory for ordinary columns; but in order to apply it, we must know where the load is; in the ordinary column, of course, we do not know where the load is; it may be an inch out from the axis of the column; so, in using an ordinary column formula, we are guessing how far the load is from the centre of the column. Of course, that is a short way and a convenient way of estimating columns in practice, but I want to call attention particularly to the fact that the theory of columns, in so far as columns are well built, is not on a particularly unsatisfactory basis. This theory was taken up by Professor Tetmyer, who published a book on columns and made a great many experiments on eccentrically-loaded columns of rather small size. He took, particularly, a couple of angles, fastened together, and loaded one of the legs, and found that the deflection and failing load corresponded closely with the values which one gets from calculation.