never be damaged in an impact between two cars at a speed of four miles an hour. There is not a coupler on the market but that will stand a greater impact force than the force necessary to close any draft gear on the market today. I have given some heights of drop that a 9,000 lb. hammer should fall before it shears off one or both lugs with nine rivets 19-32 in. in diameter. This method of testing draft gears was first used, I think, in Sept. 1908, by the Westinghouse Airbrake Co., but there 9/16 in. rivets were used. To my mind, this is the best method of determining the capacity of a draft gear. In this method of testing, the draft gear is mounted on two lugs, that are riveted to two short pieces of channels and held upright between posts. Each lug has nine rivets, each 19/32 in. in diameter, each lug carries half of the load, and the test is made by dropping the 9,000 lb. hammer from 1 in., 2 in., 3 in., and so on, until one lug is sheared off. This shearing of these rivets occurs at a pressure of about 275,000 lb. I say about 275,000 lb. for that is the average pressure that I obtained on several sets of lugs.

Now, when the 9,000 lb. hammer drops vertically on a draft gear that is supported on these two lugs that rest on a solid base with these same rivets in the lugs, they will not shear off until an approximate pressure of 275,000 lb. is reached, and in a good many tests with the same draft gear and different sets of lugs, the variation is never more than 1 in. That is, if a given gear shears off at a 16 in. drop, it might go 15 in. at another test, or if it shears off at 24 one time, it might go to 25 on another set of lugs. In other words, the variation is very small. I have conducted a test of a certain draft gear of a given make that sheared off three sets of lugs at exactly the same height, which means that this method of testing is bound to give very accurate comparison of the capacity of different draft gears.

Up to this time, in this paper, I have been talking of draft gear capacity and have not mentioned the absorbing capacity. I wish to distinguish between these two at this point. In the first part of this paper, I defined draft gear capacity as the foot-pound of work necessary to close the gear. The absorbing capacity is that which is not given back when the draft gear is released after being closed. This feature of a draft gear can be very easily obtained from the drop of the 9,000 lb. hammer by putting a recording pencil on the hammer and causing it to mark on a revolving drum. If the hammer falls 20 in., and rebounds, say 10 in., it is evident that the absorption has been half the capacity. This feature of the draft gear comes into play in the controlling of the slack of a long train in going up and down grades and in the starting and stopping of trains. If the slack should run in, and is not absorbed by the draft gear, it would run out under almost the same speed minus only that absorbed in the journal and rail.

This brings me to a point that I have often made, and that is, that we cannot expect a draft gear to last the life of the car, any more than we can expect a brake shoe to last the life of the car. They both are put on a car for the same purpose, viz., to stop it and if we expect to get any value from our brake shoes, we must expect wear. No one has discovered a metal that has any absorption of work by sliding on some other material that does not wear. Of course, some metal wears more than others under the same absorption. Some years ago I made some tests for the M. C. B. A. brake shoe committee and I found some shoes with the same coefficient of friction that varied as much as 300% in the loss of weight in doing a given amount of work. Here is a very good field for the draft gear companies. In my brake shoe committee work, we found that the loss of metal decreased very fast, as the pressure increased and the coefficient of friction decreased as the pressure increased. If we want to increase the life of a brake shoe we must increase its area. Now we are putting two shoes on a wheel and getting a saving in both. There is the same field in draft gears. We should keep the pressure between the wearing surface as low as possible and this can be done by making it as large as possible. But in no case would it pay to put enough brake shoes on a car to last as long as the car, and I think the same can be said about the draft gear.

Another thing which may be of interest is the results of some tests which I have just made in regard to the centre line of draft. Some time ago the committee on car construction made some recommendations with regard to the centre line of draft. These recommendations, when applied to most cars, fixed the centre line of draft within 2 or 3 in. of the centre of the sill. In order to get some information on this subject six sets of channels were made up. A photographic reproduction of two of them after the tests are shown in figs 2 and 3. The channels were each 15 in. high and weighed 40 lb. per foot. The centre line of draft of one set was placed on the centre of the channel of 7½ in. from the edge, and this distance from the edge was decreased by 1¼ in. until 2½ in. was obtained. Two sets of channels, with the centre line of draft 6¼ in. from the edge, were made, one set of which did not have any tie plate. The results obtained are given in table 2.

**Table 2—Maximum pressure obtained in impact test made on 15 inch 40 lb. channel with 15,000 pendulum hammer with different centre line of draft.**

| Distance from edge of channel. | Maximum pressure obtained before the channel failed. |
|---|---|
| 7½ in. | 1,155,000 lbs. |
| 6¼ in. | 1,125,000 lbs. |
| 5 in. | 960,000 lbs. |
| 3¾ in. | 723,000 lbs. |
| 2½ in. | 662,000 lbs. |
| 6¼ in. without tie plate | 744,000 lbs. |

It is evident from this table that the centre line of draft should be for maximum strength within 2 in. of the centre line of the sills, and that the tie plates are of great value in strengthening the sills. By looking at fig 2 it will be seen that when the line of draft is on the centre, both upper and lower flanges are bending, while with the line of draft 3¾ in. from the edge, as shown in fig 3, nearly all of the bending is at a place in the edge of the channel closest to the line of draft. This is nothing extraordinary, for if you eccentrically load any two pieces of steel, the one close to the load is going to take most of the work and the ultimate strength of the system is reduced.

I have attempted in this paper to bring forward two or three very important things in the selection of draft gears and the design of freight cars. One of the most important things is, we will have to increase the travel of the draft gear above that thought sufficient some years ago when it was felt that 2 or 2¼ in. was as much travel as we should have. But I am ready today to say that we should have at least 4 in. of travel, or possibly more, in any draft gear. It is evident from the first of my paper that this arrangement is going to allow us to materially increase the capacity of the draft gear when we design it under four or more inch travel.

Another thing that is of importance to railway men today is, how are they going to know what capacity of draft gear they are getting. I am confident that the best method for them to use is the rivet shearing test, as already described. Whether it be nine rivets 9/16, ten rivets of 9/16, or any other number of rivets, does not enter into the subject. What they should have is a set of lugs that will shear just above the force which is necessary to close the gear under test. I can conceive how a gear can be designed for a final pressure of 350,000 lb., then a test of rivets shearing off at 275,000 lb. would not be fair. But in any design of a lug, the lug should be made much stronger than the rivets, in order that the lugs will not bend down and the gear show a false capacity. I can see how a lug may be built and give false capacity of draft gear, but the lugs should be designed stronger than the rivets. I have not found a draft gear today but that will close before it shears off nine 19/32 in. rivets. There may be some, however, on the market.

One thing that is important in the design of a freight car is that the underframe of the car should be made stronger than the coupler. It has been the coupler in the past that has been saving the car after the draft gear went solid. Men who repair cars appreciate the large number of couplers that fail. I am wondering if when we put on the new M. C. B. coupler, it is not going to be the underframe of the car instead of the coupler that is going to fail when the draft gear goes solid. Especially is this true if we move the centre line of draft out from the centre of the sills or leave off the tie plate, as shown in the latter part of this paper, because then the pressure of only 662,000 lb. destroys the sills with the centre line of draft 2½ in. from edge of channel. The new coupler will stand this and more in compression, which means that it will not be the coupler, but the underframe, and if the underframe, it will cost considerably more to replace than the coupler. I assume that everybody here knows that a friction draft gear is superior to a spring gear, but I do not believe that all of you know how much this difference is. The highest capacity spring gear in use, made of two M. C. B. class G springs will fully protect your 100,000 lb. car and lading, at a switching speed of a little less than two miles an hour. There are friction draft gears in general use on thousands of cars that will protect this same car and lading at 4.5 miles an hour. Also, there are many gears on the market that will fall between these two extremes and each of these gears has a definite speed at which it will protect the car. But if you should attempt to switch your cars at four miles an hour while equipped with a spring draft gear, that only protects the car at a little less than two miles an hour, the coupler, underframe and lading are bound to suffer. Either the coupler or underframe will fall if this speed of switching is kept up, while, should this same car be equipped with the highest capacity gear, spoken of above, it could be switched at four miles an hour without any damage to underframe or coupler.

Unless we put a draft gear of sufficient capacity to keep it from going solid, the force is going to the strength of the weakest part. If this is the coupler it will be from 400,000 to 700,000 lb. on