had a coupler that would stand about 500,000 lb. I would want to have an under frame that would stand over 600,000 lb., and two 25 lb. channels with 19 sq. in., including cover plate, would give an under frame plenty strong enough. The coupler is going to fail before the strength of the sill is reached. If you have a coupler going 700,000 or 800,000 lb. you must go to a centre sill that will stand a greater load. I want my coupler to break first. If that will stand a million pounds we should have an underframe stronger than that or the underframe is going to fail first.

K. F. Nystrom: Two 12 in. channels will not safely stand a million pound shock?

L. E. Endsley: I said that two 12 in. channels of 25 lb. per foot would stand 600,000 lb.

K. F. Nystrom: If you allow, say, 16,000 or 20,000 lb. per sq. in., you have got to get more than 12 in. channels.

L. E. Endsley: You will not bend the sills until you have a stress of 35,000 or 38,000 lb. per sq. in. You will shorten it a little as you get above the elastic limit, but you won't bend it until you get a force which is equal to over 35,000 lb. per sq. in. In the tests mentioned in the paper we used an accurate strained gauge that is constructed to read to 0.0002 parts of an inch. If there is any give in that sill over 0.0002 then this strain gauge will show it. If the webs of the channels are as thick as they are in a 12 in. channel that weighs 40 lbs. per foot the force per sq. in. to destroy or bend the sill is increased. In two sets of channels of the size just given, the area would be approximately 28 sq. in. for the centre sills with the cover plate included. In a test of these channels the force to destroy them was over 1,300,000 lb. or over 47,000 lb. stress per sq. in.

T. H. Curtis: I think Mr. Endsley's paper brings out the necessity of not having too much eccentricity through the location of the draft gear in relation to the centre sill. I would refer him to the table in the paper where the draft gear has been 2½ in. from the edge of the channel. It is very little more than half the strength of when it is in the centre of the channel. To get away from this eccentricity it seems to me the trucks should be designed so they will be as low as possible and the spring draft nearer to the centre of the sill. There is another advantage gained by this and that is that it will lower the centre of gravity of the car body. With respect to broken draft gears: one point is that the repair men do not always know when they should be repaired and when they should be replaced. I think the suggestion made by Mr. Nystrom is worthy of consideration and shows the need of a draft gear that will automatically take up the slack caused by wear and abuse. I have not heard anything said here about the auxiliary to the draft gear, which is the buffer block. That is something which takes up some of the greatest shocks and if that were so set that the coupler horns would strike before the draft gear became solid it would be a great advantage as it is something which the repair men can see readily and is something which can be easily fixed.

Mr. Hatch: I would like to enquire of Mr. Endsley what effect it would have on increasing the length for the distance of travel on train slack, bearing in mind the difference in loaded cars, difference in piston travel, and so forth. I refer particularly to passenger equipment.

L. E. Endsley: Mr. Hatch has opened a subject that I had hoped to have the best man in the United States with me tonight to reply to, but I received a telegram that he could not be here. There are two entirely different things in this subject, for instance, slack is movement between two cars without any resistance. But the draft gear movement is entirely different. Some men have I think mistaken draft gear travel for slack, and if you increase your slack between two cars you are going to increase the evils due to that slack. Let us assume for instance that you have a foot slack between two cars. You would get one car going in starting the train, and would go a foot before you picked up the next car, and in going that foot, probably could increase your speed a mile an hour or so, but if in going that foot you had resistance equivalent to a large number of foot pounds, and if you have between the two cars 4 in. of draft gear travel under 200,000 lb. final force your average will be 100,000 lb. Now if this force acts through between each car and no slack, the other car would be moving almost before there was any difference in speed, the slack happens after the gear goes solid. If there was a lot of slack on a car I would expect a shock but if I had resistance that the locomotive could not take entirely up, and it had to start the cars with resistance, then I would have a little give between the cars, and when picking up the last car of the train, each car in the train would be moving at almost the same speed. I think one of the things we have overlooked is the advantage we are going to gain by cutting down the slack, that is moving without any resistance whatever. I would be very glad if I had the assistance here tonight of W. V. Turner of the Westinghouse Air Brake Co., to discuss this question more fully, as it is a very deep one.

J. Hendry, Master Car Builder, G.T.R.: In my opinion an underframe, properly designed and constructed, having been obtained, the most important part of the design to consider is the type of draft gear. In this connection I think it is generally conceded that a modern friction draft gear gives the greatest protection, as it reduces the cost of maintenance and all other expenses incident to failures. A careful examination of cars placed on shop tracks for repairs will, I am convinced, show that probably 70% are placed on account of defects that have developed due to shocks, and I believe investigation into this cause of damage to lading indicates that a large percentage can be traced to the same cause. If such is the case, and we all know it is, something should be done to relieve the equipment of such ravages.

A great deal of attention has been given to the design of the underframe construction of freight equipment, but the desired results will never be attained unless some device, between the frame and the coupler, is installed which is especially designed to destroy or absorb the force of the blow. A car may be properly designed and constructed through, but if it is not protected against the force of shocks, which all freight cars are subjected to, the weakest point will begin to fail. Springs have been used, varying from 18,000 to 60,000 lb. capacity and gave good protection some years ago, when cars were of light capacity and were handled in short trains; but they do not meet the requirements of today and a large number of roads have started to replace the spring gear with friction devices that have from three to four times the shock-absorbing capacity that can be obtained from the spring gear. In a friction gear there should be no recoil. The force exerted by the recoil of a spring is practically as great as the force to compress it, and results in much damage to equipment handled in long trains. A reduction of car failures is sure to follow in the adoption of the friction draft gear, which means a great saving to a railway, because of the increased earning power of the cars and the decreased cost of maintenance, lost and damaged lading accounts, delays and interruptions of traffic, transfers of lading and switching through various terminals. The draft gear, I consider, is one of the most important factors in the question of car maintenance and other expenses incident to car failures. It is the only device that we can apply to a car to protect it and its lading from being damaged. It has no other function to perform. It must destroy shocks from impact, shocks from pulling and shocks due to recoil. A few of the damages occurring to cars due to the draft gear failing to perform its work are as follows: If we could use a draft gear between the coupler and the car that would absorb the heavier shock, we would do away with broken couplers, but with improved friction draft gear this may be obtained by continuing to use our present style of couplers without increasing their weight. While knuckles wear out in service, yet a great many of them break; and here again would relieve the knuckle by absorbing the shock. What is true of the coupler and knuckle, is also true of the knuckle pin, either the draft gear absorbs the shock, or we will have to increase the size of the pin or have the knuckle so arranged that when locked in position the strain will not come on the pin. Failure of coupler yokes is also due to shock. These are, I think, being replaced by other forms of attachments, on account of pocket rivet failures, on account of pocket rivets in shear under impact. By eliminating this feature the wrought iron or forged steel yoke with 1¼ x 5 section riveted to the coupler with two 1¼ in. rivets can be operated with very few failures. No one will deny that draft springs are destroyed by shock, but with a properly designed friction draft gear, the failures are few, for the reason that draft gears are not driven solid, even though the draft gear receives a shock sufficient to close it. Draft lugs, draft arms, draft sills, deadwoods and end sills all fail, simply because the draft gear fails to destroy the force of the blow. I do not say that a friction draft gear will cure all the ills to which the freight car has fallen heir to, but I do know that it helps to maintain freight cars in service and keep them off the repair tracks; thereby increasing the earning capacity and efficiency of the freight car. I believe that a standard specification for the testing of draft gear, to determine its shock-absorbing capacity and amount of recoil, should be established to obtain, by means of physical tests, their worth or efficiency as a shock destroyer.

E. J. McVeigh, General Storekeeper, G.T.R.: If the fact that I have seen a vast number of broken couplers and draft gears gives me a right to claim some knowledge of these things, then I should be an expert, but I am afraid such is not the case. When I first heard that Mr. Endsley was coming to give us a paper on draft gears, my first thought was, "Have we found a Moses at last who will lead us out of the wilderness of broken and disabled cars?" While Mr. Endsley has given us much valuable information, and if we make proper use of it we will