the values in column I. by those in column IV. and then by the grate area, which is 17 square feet.

Columns VII. to XIV. were obtained in a "cut and try" method, which is shown by the following example: When using 110 lbs. of coal per square foot of grate area under a steam pressure of 200 lbs., we get at a 48% cut off;

From the curve in fig. 7, 24.9 lbs. of steam per i. h. p. per hour;

From the line in fig. 9, 92.2 lbs. mean effective pressure.

$$\text{Thus, i. h. p.} = \frac{16325.1}{24.9} = 655.6.$$

Also, i. h. p. = 4 (92.2) (.012144) (146.2) = 654.6.

At 48.2% cut off we obtain from the curves in fig. 7 24.9 pounds of steam per i. h. p. per hour, which gives i. h. p. = 655.6, and from the curves in fig. 9 92.7 mean effective pressure, which gives i. h. p. = 658.2.

By looking at the above sets of values, it can be seen that at 48% cut off the i. h. p. figured from the basis of lbs. of steam per i. h. p. is greater than that figured from the basis of the m. e. p., and at 48.2% cut off just the reverse is true. Therefore, the proper values must lie somewhere between 48 and 48.2% cut off.

The proper value of 48.1% cut off was found to give the same i. h. p. figured from the pounds of steam per i. h. p. per hour as figured from m. e. p.; that is, with 48.1% cut off, the steam per i. h. p. per hour is 24.9 as obtained from the curve and gives an i. h. p. of 655.6. The m. e. p. at this

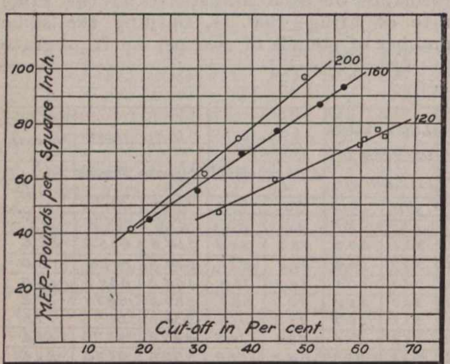

Fig. 9.—Relation Between m.e.p. and Cutoff for Superheated Steam Locomotive.

cut off is 92.4, and gives an i. h. p. of 656.0. These are so near the same that the 655.8 value was taken as the i. h. p. developed while burning 110 lbs. of coal per sq. ft. of grate. The four values mentioned above were used in the tables. The same process was used in determining the values for each line of table V.

Column XV. of table V., which gives the per cent increase in indicated horse power of the superheater locomotive over the other locomotive, when using the same amount of coal, equals column XIV. minus column XIII. divided by column XIII. and multiplied by 100.

Discussion of Results.

INCREASED POWER DUE TO SUPERheating.—It can be seen from column XV., table V., that the increase in power due to superheating, when burning from 110 to 130 lbs. of coal per sq. ft. of grate surface per hour, varies from 22.6 to 13.0%. Also from the values in this column it can be seen that for any steam pressure the per cent increase of power decreases as the coal consumption increases, and that for any coal consumption, the increase of power increases as the steam pressure increases.

THE EFFECT OF INCREASING SIZE of Cylinder for Maximum Power.—By comparing the values of equivalent pounds of steam per i. h. p. per hour it will be seen that they are considerably larger than the best performance of the locomotive as obtained at a lower cut off; that is, the cut off of maximum efficiency for 160 lbs. steam pressure is approximately 37%, while the cut off as obtained under 120 lbs. of coal per hour is 55.5%. The relative steam consumption for these two values of cut off is 25.2 and 26.7 lbs. per i. h. p. per hour, respectively. It will be seen that the increase in power to be accomplished by having the cut off at the proper point to give maximum efficiency is about 5.6% as is shown in column VIII. That

$$\text{is, } \frac{26.7 - 25.2}{26.7} \times 100 = 5.6\%.$$

In order to show this more clearly, the values in table VI. have been worked out.

Columns I., II., III. and IV. were taken from columns II., VIII., X. and XII., respectively, in table V., at 120 lbs. of dry coal per sq. ft. of grate surface per hour. The values in column V., which give the cut off at maximum efficiency, were taken at the lowest points of the curves in fig. 7. The values in column VI., which give the equivalent pounds of steam per i. h. p. per hour at maximum efficiency, were taken from the curves in fig. 7 at the points of cut off shown in column V. The values in column VII., which give the m. e. p. at maximum efficiency, were taken from the curves in fig. 9 at the points of cut off shown in column V. The values of column VIII., which give the per cent. increase in indicated horse power, equals column III., minus column VI., divided by column III. and multiplied by 100. The values in column IX., which give the diameter by cylinders necessary to obtain maximum efficiency, equal 16 times the square root of values given in column IV., divided by the square root of values given in column VII. The following sample calculation will show this more clearly. The diameter of the cylinders at present is 16 ins. The ratio of this to the new diameter required to give the same indicated horse power must be inversely proportioned to the roots of the mean effective pressures. For 200 lbs. pressure

$$\frac{X}{16} = \frac{\sqrt{96.0}}{\sqrt{70.0}} = \frac{9.86}{8.38}$$

$$X = 18.82$$

where X. is the new diameter of cylinder.

The average of the three values in column IX. is about 18¾ ins. Now, if the locomotive were equipped with 18¾ in. cylinders, when using 120 lbs. of coal per square foot of grate, the cut off could be at the most efficient point to obtain maximum power.

Under these conditions there would be an increase in power as shown in table VII., or, in other words, the increase in power of the superheater locomotive over the other for the 160 and 200 lbs. pressures would be about 25% if the size of the cylinders were increased to 18¾ ins., whereas at present the increase is about 20%.

Table VII., showing the increase of power of the superheater locomotive over the other when using 120 lbs. of coal per sq. ft. of grate per hour if the cylinders were increased to 18¾ ins., is given below.

Steam Pressure	I. H. P.		Per Cent In. in I. H. P.
	Sat.	Sup.	
200	567.8	217.0	26.3
160	553.1	689.0	24.5
120	487.2	636.0	30.0

Report of Committee on Car Construction.

The Master Car Builders' committee, W F. Kiesel, Jr., Assistant Mechanical Engineer, Pennsylvania Rd., chairman, reported as follows:—

The following letter from D. F. Crawford, General Superintendent Motive Power, Pennsylvania Rd., gives the reason for this investigation:—

Prior to the 1911 M.C.B. Code all steel underframe and all steel cars were subjected to the same combinations and the same delivering lines' defects as wooden underframe, composite underframe and all wooden cars were. The consequences were that in interchange defect cards were being requested for damage which in no event would be repaired. In order to correct this situation rule 43 was introduced. The interpretation of this rule is, in effect, that a steel underframe car or an all steel car will not be damaged in fair usage; consequently, the combinations should not apply, and the handling company was made responsible for all damage which necessitated repair, except such damage as might occur through corrosion and weakening of the parts.

"I have been advised that in some of the new all steel and steel underframe equipment which has been constructed recently, that in some instances the centre sill section has been reduced to such an extent that the steel and steel underframe cars are no stronger, if as strong, as the wooden cars, and under rule 43 the owner will receive the same protection as he would if the car had been of proper strength.

"It would seem desirable for the M.C.B. Association to set some minimum strength for steel cars which would adequately protect the handling line, specifying such cross sectional area of centre sill as may be felt to be proper and fair, and cars which have less than this cross sectional area will be considered the same as wooden underframes or composite underframe cars in so far as combination defects are concerned. I would suggest that this may be made one of the subjects for committee work next year, as I do not consider it proper that the burden of maintaining weak cars should be put on the handling line."

The subject has been divided into two parts:—(a) Centre sills for existing cars. (b) Centre sills for new cars.

The only precedent we have is that of wooden cars. The experience with steel and steel underframe cars extends over about 15 years. This experience covers a large number of car types, showing great variations in end strain resisting qualities.

It was agreed that the relative values of steel and wood used in car construction for direct tension or compression should be based on the elastic limits of these materials, and that the committee use a ratio of four for the elastic limit of steel to that of oak or yellow pine.

Compared with a wooden car having two 4 in. by 8 in. centre sills, an equivalent steel car must have an effective centre sill area of not less than 16 sq. ins. between the points where end strain takes effect. The strains in car underframes due to lading do not add greatly to the stresses from end shocks. As a rule, a loaded car is less liable to damage from end strains than an empty car, for which reason it will not be necessary to introduce load strains, but base the minimum area and end resisting strength on end strains only.

Modern steel cars have the centre line of draft at varying distances below (seldom