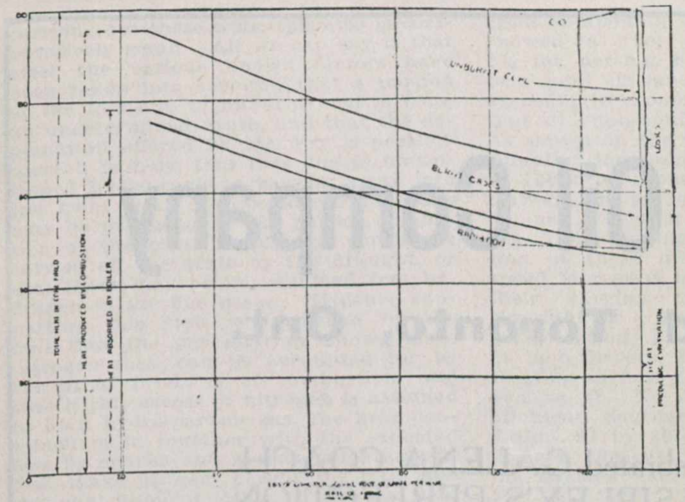

FIG. 1.

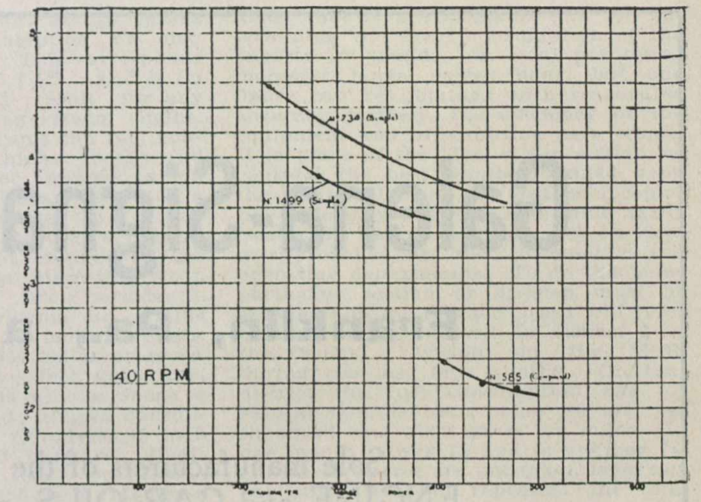

FIG. 2.

burned. The losses are however, nothing like as serious as those which take place in the conversion of the heat in the steam into work, and are only due to the combustion not being entirely perfect, the radiation of heat from the boiler, and to the heat contained in the gases that pass away into the stack. Under favorable conditions the sum of these losses may only amount to about 20%, so that 80% of the heat developed by the fuel may be actually present in the steam delivered by the boiler. In locomotive practice, however, boilers are not worked under as favorable conditions as are stationary boilers, on account of the enormously larger amount of steam that has to be generated by a boiler of a given size. In place of evaporating 3 lbs. of water per square foot of heating surface per hour and burning 15 lbs. of coal per square foot of grate, as much as 16 to 18 lbs. of water are evaporated and 120 to 140 lbs. of coal burnt.

This increase in capacity, while necessary in order to obtain the output from a locomotive boiler that would require a whole battery of stationary boilers, is only rendered possible by a sacrifice of economy, or in other words the efficiency of the locomotive boiler is generally considerably less than the 80% mentioned above. The reasons for this loss in efficiency in the boilers at the St. Louis Exposition were thoroughly investigated by Lawford H. Fry, and figure 1 shows one of the results of the caluculations made by him, which is exceedingly interesting. It is one of several which he presented in his paper on "Combustion in Locomotive Fireboxes" before the Institute of Mechanical Engineers, and refers to the trial of the New York Central balanced compound engine no. 3000. The diagrams for the other engines are generally similar, with some exceptions that will be mentioned later.

The efficiency of the boiler, which is shown by the lowest line, is slightly over 70% when coal is burnt at the rate of 30 lbs. per square foot per hour, and is gradually reduced to about 46% as the rate is increased to 120 lbs. per square foot per hour. The space between the lowest line and the next above it represents the heat radiated away by the boiler, so that this line shows the total heat absorbed by the boiler from the coal. The space above this represents the heat escaping in the hot gases passing out through the front end, while the space between the two upper lines is the loss from unburnt coal. The loss from imperfect combustion, or from the formation of carbon monoxide, is represented by the space between the highest line and the top of the diagram. This diagram is very interesting. In the first place it shows that at low rates of combustion the locomotive boiler is just as efficient as any, as the line showing the heat utilized would evidently be about 80% at a rate of 20 lbs. per square foot per hour, and in the next place, the losses from imperfect combustion are exceedingly small. This loss was not, however, as small as this in all the engines tested, as in one of them it became about 16% at the maximum rate of combustion. This is thought to have been due to insufficient ashpan openings, and it attracted general attention to that detail of the engine.

On most engines, however, this loss was small, and it is evident that from the cause, there need not be very much loss on a locomotive. It must be remembered that the firing at St. Louis was about as perfect as possible and the running conditions uniform, but from the fact that insufficient air causing a dull fire ran this loss up to 16% in place of 2 or 3%, it is evident how easily a loss in efficiency may be caused by heavy or intermittent firing which does not keep the fire in a clean bright condition. The heat wasted by the burnt gases is almost constant. This peculiar fact due to the decreased amount of air per pound of coal required at the higher rates of combustion which compensated for the increased temperature at which the gases passed into the front end. The same thing occurrs in all the tests and shows how well the fires were kept free from holes and the grates properly and uniformly covered.

The important loss, which increases as the rate of combustion increases, is that from unburnt coal. This loss is not entirely explained. The larger part of it is accounted for by the sparks and coal pulled through the tubes and stack without being burnt, but this is not sufficient to account for the entire loss. The loss from sparks is known to be about 20% of the total coal burnt, at the highest rate of combustion, and the balance of the loss is accounted for in different ways. Mr. Fry considers a large portion of it is due to unconsumed hydro-carbons, but it is not definitely known whether this is really the correct explanation. It is possible that the line showing the heat lost from the burnt gases should be rather higher, which would decrease the loss shown as unburnt coal. There is also a loss due to good coal shaken down into the ashpan, but with the care taken in

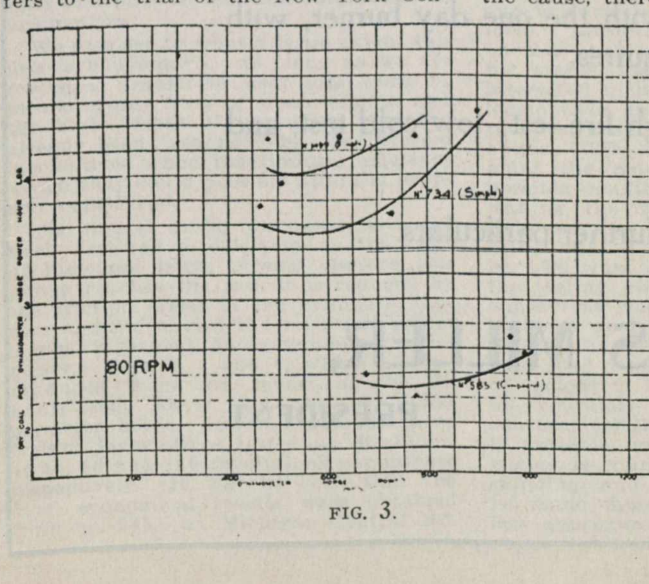

FIG. 3.

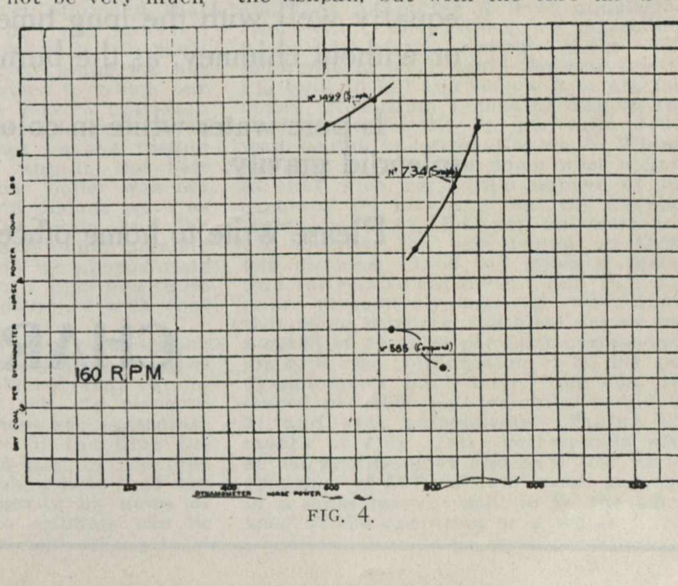

FIG. 4.