7th. The alternate expansion and contraction permissible by the corrugations to the large combustion flues will tend to loosen the scale which may form on the water side of these sheets.

Next, considering the advantages to be had through the operation and efficiency of this boiler:—

1st. An arrangement which will provide a generator and container for an indicated working steam pressure of 250 lbs. per square inch. The economy resulting from the use of a high steam pressure will readily be noted from the fact that while 6.6 heat units are required to raise a pound of steam from 150 to 200 lbs. pressure, only 12.2 heat units are required to increase the pressure from 150 to 250 lbs., which is an increase in pressure of 33⅓% at a proportionately reduced fuel cost of 15%. In addition, the higher the steam pressure, the more nearly superheated will be the steam itself, and in high pressure and superheating lie one of the most essential features conductive to economy and efficiency, especially in connection with obtaining the most successful results in the complete expansion of steam through compounding, resulting in an increased tractive power at a largely reduced cost per unit.

2nd. A furnace equipped with an underfeed method of automatic mechanical stoking and mechanical forced draft, which will promote the most perfect combustion, and permit of the steam, which is now used for inducing the draft and exhausted to the atmosphere, being used to develop further work by expansion in the cylinders and then to be released to heat the boiler feed water.

3rd. The longer, slower and more natural travel of the gases from the furnace to the atmosphere will result in a greater opportunity for conduction and convection, reduced wear on the tubes and sheets, and the gases of lower temperature will have a better chance to be absorbed by the water.

4th. Less loss of fuel through cinders, which are practically unconsumed coked coal, being drawn out of the furnace through the tubes and ejected into the atmosphere, and from unconsumed coal falling into the ash pan through the grates.

5th. Less liability to set out fires along the right of way.

6th. The larger proportional diameter of the flues and tubes will promote and complete the combustion, for the reason that they will carry the flame farther than in the case of the smaller two-inch tubes that lead directly from the furnace and where the flame comes into immediate contact with the larger quantity of incombustible gas beyond the air supply. Besides this, the temperature of the smaller tubes, which are surrounded with water, is so reduced that the flame is soon cooled, and the igniting temperature of combustion cannot take place after the gases enter the ordinary smaller two-inch tubes.

7th. The corrugated combustion flues provide a larger free draft to carry a long flame, and which, by facilitating a uniform transfer of heat, can practically be considered a continuation of the firebox heating surface, that in itself is so much more efficient than the smaller tube heating surface. The corrugations to these flues, while increasing the heating surface, also serve as baffles and retard the passage of the hot gases and flame, increasing the efficiency of the boiler. Their use will also maintain the combustion chamber gases at a high temperature, resulting beneficially in the superheating of the direct and exhaust steam to and from the high pressure cylinder to the low pressure cylinder, which will overcome the losses in the latter through cylinder condensation.

8th. The firebox and combustion flue heating surface, located at the lowest position in the boiler in contact with the water of the least degree of temperature, will facilitate steam generation on account of the distribution at this point of the most intense and uniform heat the entire length of the boiler proper. With the present type of locomotive boiler the intense heat is at the rear, or firebox end only, and the front, or smokebox end, contains the lowest degree of temperature. By noting the travel of the gases in the proposed boiler it will be seen that with the arrangement of the furnace under the extreme ends of the boiler tubes at the smokebox end of the boiler, and the combustion flues under the forward ends of the boiler tubes in connection with the combustion chamber at the front of the boiler proper, a much more uniform distribution of the heat is provided to the water to facilitate steam generation, and to allow for the equal contraction and expansion of the boiler.

9th. An arrangement of the furnace combustion flues and the boiler tubes which will promote combustion and transmit to the water, to a greater extent, the heat contained in the furnace gases before they are released to the atmosphere.

Presuming that through imperfect combustion, carbon dioxide, carbon monoxide, hydrogen and nitrogen will leave the furnace and enter the combustion flues, the latter and the combustion chamber will allow sufficient room for the flame to carry, and the association of these gases with each other and the additional heated air, will tend to promote a more complete combustion by producing a greater proportion of carbon dioxide, oxygen and nitrogen gases before the entrance of these gases to the 2½ in. boiler tubes, and their consequent release to the atmosphere.

The travel of the gases also being for 48 ft. in contact with the water surfaces, as compared with at the most 27 ft. in the present type, this will reduce the temperature of the furnace gases before they are released, from the present temperature of from 700 to 1,200 degrees Fahr. to between 450 to 550 degrees Fahr., the difference being due to the heat units which will be conducted by the sheets to the water to assist in generating steam.

10th. The boiler tubes being 2½ ins. outside diameter, as compared with the usual practice of 2 ins., will provide freer draft, and in connection with mechanical forced draft and automatic stoking a more natural and slower passage of the gases will be obtained through these tubes, so that their length will be more fully utilized, and there will be less liability to choke and to become inefficient through obstructing the passage of the gases.

11th. The smaller tubes being located high in the boiler barrel will give less trouble through incrustation and the clogging of the water spaces between the crown and firebox sheets, while the larger flues being near the bottom of the boiler, where they will be in contact with the colder water and the most intense heat, will promote a more decided circulation and steam generation, and the steam generated at this point will have a free opportunity to disengage itself. There will also be less liability of an accumulation of incrustation around the flues at the firebox flue sheet connection, as must now be contended with, on account of the scale and sludge washed from the crown sheets lodging on the small tubes near the firebox tube sheet connection, restricting the contact of the water with the intensely heated sheets at this point, and resulting in mud burning, failure and renewals.

12th. A large proportion of firebox, combustion flue and boiler tube heating surface, which will facilitate the generation of steam by their absorption of more heat. If it is necessary to provide additional heating surface in this type of boiler in order that it may be used in connection with a larger capacity locomotive, an arraagement of extended wagon top will be located at the first course of the cylindrical shell, which will permit of additional boiler tubes being located higher in the cylindrical portion of the boiler proper, and at the same time provide for the steam space that will be required, due to the increased height of the normal water level.

13th. A large storage space for water and steam.

14th. An arrangement of interior parts which will provide every opportunity for the free circulation of the water around the plates subject to the most intense heat, and ample disengaging surface for the generation of steam.

15th. Less water leg and restricted circulation, and consequently more heat storage and reservoir capacity, on account of firebox of less depth and more clearance between internal parts, which can be taken up for water storage.

16th. The dome being located at the front of the boiler barrel gives a shorter distance for the steam to travel to the cylinders, and less loss in pressure through friction. When working hard on grades there will be more steam space at this point, with the same comparative water level and less liability for the engines to prime on account of saturated steam.

17th. Ample capacity for steam generation being provided to fulfil the requirements of the cylinders without forcing, the loss through steam with entrained moisture delivered from the boiler, the percentage of which moisture increases as the rate of evaporation is increased, will be much less.

18th. The actual length of the flue water-joint in the firebox tube sheet being but 220 inches, as compared with from 1,900 to 2,500 inches, which is the practice in the same capacity boilers of the present modern type, the liability for losses and failure through firebox leaks will be reduced, in that proportion, from 900 to 1,100%, and the crown and side sheets to the firebox being made of one instead of three sheets will further reduce the liability for expense and failures through the same cause.

19th. When operating the locomotive at its maximum capacity, up grade, the volume of the steam space in the boiler will automatically increase, instead of decreasing as in the present type, at the dome location from which the steam is drawn for the engines, and this will insure less liability for priming and the heat losses through steam with entrained moisture being delivered from the boiler.

Also when tipping over summits, the water will flow to the front of the boiler and increase the level to protect the boiler tubes where they are the most intensely heated, while the rear or the cooler ends of the top rows of the same will not be damaged, even should they be entirely uncovered.

The flow of the water in the boiler will automatically favor steam generation, by increasing the water and steam volumes where most needed in the boiler to absorb the heat, and to maintain the working pressure when the locomotive is being operated at its maximum capacity over rolling country.

COMBUSTION.

A steam generator, is composed of two distinct parts, each with its independent function: the furnace for the proper combustion of the fuel, which is performed to perfection when the greatest amount of heat is obtained from a given weight of combustible, and the boiler proper for the transfer of the heat thus generated into useful effect, and to evaporate water into steam, which function is fulfilled completely when the greatest possible quantity of heat is thus utilized.

As a boiler is for generating steam, it can utilize for that purpose heat only of a greater intensity or higher temperature than the steam itself; therefore the gases of combustion cannot be reduced below that temperature and