Oil holes, grooves, cups, siphons and swabs arranged as required to lubricate the balance of the motion gear, center and other bearings, with engine oil.

Cylinder oil to lubricate all sliding surfaces exposed to and confined in steam under pressure.

No water service to be connected with any bearings.

Speaking tube, one, from front to rear cab, 1 in. gas pipe, with flexible mouthpieces.

Engine bell, operated with pneumatic ringer.

Steam whistle, single tube, long distance pattern.

Pressure gauges, two diaphragm 500 lbs. capacity gauges, one each located on boiler in front and rear cabs. One each simplex steam heat and duplex air brake equipment diaphragm 160 lbs. capacity gauges located in engineer's cab.

Water level gauges, water gauge glass at rear of boiler for fireman's information, and water gauge glass and three try cocks in engineer's cab.

Draft exciter, a ¾ in. live steam nozzle located in smoke-box centrally with smoke stack, to be used as necessary when blowers are not running.

Loose equipment as required, for train rules, operation of locomotive, and emergency.

OTHER CONSTRUCTION

Cab, front, wood framing and roof with steel stay plates secured to exterior of sides and rear, and steel plate front.

Cab, rear, steel plate throughout.

Running boards on engine and tender, wood, bound with angle iron.

Pilot, steel throughout; framing, flat bar and horizontal angle steel stays, riveted.

Buffer beams, oak, to front of engine and to front and rear of tender frame; bolted to steel buffer plates secured to frames.

Tool equipment and drinking water boxes, wood, located and secured on flat deck to front of tender water tank.

Painting: Engine—Eccentrics, straps and blades painted vermilion; lettering and numbering, aluminum leaf; usual bright work in and outside cab, polished; inside of front cab, material wood; all other parts painted black. Tender—Raised figures of aluminum riveted to proper location on outside of side and rear sheets; unjacketed portion of tank painted with graphite; all other parts painted black. Boiler—Interior painted with a protective coating to prevent corrosion.

In the construction, malleable and steel castings to be substituted for the present practice of brass and iron castings, pressed steel and forged wrought iron, and all cast iron bearing faces to be chilled, wherever practicable. Forged wrought iron, machined, case-hardened and ground to finished size to be used when consistent, in preference to forged or rolled steel for all except axle and crankpin bearings and main and siderods. Brass bearing metal of a suitable formula to be used in place of the so-called anti-friction metals and bronzes. Antimonial lead to be substituted for babbitt metal. All operating mechanism to be concentrated, and the general construction arranged with all the regard consistent to the engineers, firemen, shop and roundhouse men who must operate, build, maintain and handle the power.

THE REQUIREMENTS FOR A PERFECT LOCOMOTIVE STEAM BOILER.

It is a thankless statement when one makes claim of a certain per cent. in saving to result from the use of any so-called improved machines or methods, but in consideration of facts resulting from both practical and theoretical experience, a locomotive construction such as set forth in the foregoing proposition and design, as compared with one of the same haulage capacity of the present almost universal American type, when operated under similar conditions, must necessarily bring more net returns and at no loss of efficiency. The following subjects are, therefore, entered into with the intention of substantiating to a more or less degree, that the features embraced will effect, at least partially, the results which must be forthcoming from locomotive service at an early date.

The requirements for a perfect steam boiler for modern locomotive service are as follows:

1st. A simple construction throughout of iron or steel, and of the best material sanctioned by use; perfect in workmanship, durable in use, and not liable to require early repairs.

2nd. A large factor of safety and a great excess of strength over any legitimate stress; so constructed as not to be liable to be strained by unequal expansion and contraction, and the least possible number of joints exposed to the direct action of the fire.

3rd. Ample disengaging surface, to insure a steady water level and dry steam, and to prevent foaming.

4th. A steam and water capacity sufficient to prevent any fluctuation in pressure or water level.

5th. A constant and thorough circulation of water throughout the boiler, so as to maintain all parts at one temperature.

6th. All parts readily accessible for inspection, test, cleaning and repairs, as this is of the greatest importance as regards safety and economy.

7th. A boiler proportioned to the work to be done, and capable of working to its full-rated capacity, with the highest economy and efficiency.

8th. A disposition of heating surface, to thoroughly absorb the heat.

9th. A combustion chamber so arranged that the combustion of the gases, which is commenced in the furnace, may be completed before they are released to the atmosphere.

10th. Straight tubes, which can be readily cleaned and looked through.

11th. Cheapness of reserve parts so that the cost of maintenance may be low.

12th. Freedom from expansion and contraction.

13th. Economy in space per unit of power generated.

14th. Large and unrestricted draft area.

THE FEATURES OF THE PROPOSED BOILER.

Considering the advantage of the construction and arrangement of the proposed type of boiler as compared with the present almost universal American design, the following are some of the constructive features which have been embodied, and which are essential to bring about results:—

1st. A straight, horizontal, self-contained, multitubular, return-draft, large capacity boiler, combining strength, freedom from defects on account of contraction and expansion of the plates or stays, accessibility for inspection and repairs, and economical as regards cost to build and maintain.

2nd. A largely reduced length of water-joint seams in the furnace, which through the direct contact with the flame and the intense heat, are liable to become defective and leak, resulting in the consequent failure of the boiler to make steam, delays to train service, excessive waste of both water and fuel, and expense for repairs and renewals.

3rd. The corrugated combustion flues leading from the furnace to the combustion chamber, are adapted by the construction and thickness of the metal to facilitate the uniform transfer of heat, and at the same time permit a free expansion and contraction of the boiler. They also possess decided resistance against collapsing, and by sufficient elasticity in the direction of their length, readily accommodate themselves to alterations in dimensions due to change of temperature in the boiler, thus removing all excessive stress from the tube sheets. The three corrugated, as well as the four plain flues, to be riveted to the furnace flue-sheet flanging, with the joints not exposed to the direct action of the fire, reducing the liability for failure or leakage, and presenting opportunity to make substantial repairs when such are necessary.

4th. The boiler or expanded tubes being away from a direct contact with the flame, presenting less liability for these joints to leak and give out at the tube sheet connections as a result of mud burning, corrosion, incrustation, the effect of the chilling of the beads of the tubes through leakage, and the consequent continual working on all of the tubes at this point as in the present type of boiler, which causes entire failure and necessary resetting, increasing the cost for maintenance.

5th. A shallow fire-box, that will be less affected from the contraction and expansion, which causes liability for the rupturing of the side and end sheets, and the breaking of stay-bolts. This depth of fire-box will largely reduce the number of flat sheet stays required, and overcome undue stresses at all the joints in the same.

6th. It will also provide an arrangement of fire-box sheets, which will be located near the fire area, obtaining the greatest advantage of the heat from the action of the flame, giving more intense action for the generation of steam at the location of the greatest heat, without the resulting disadvantage usually forthcoming from shallow fire-boxes on account of the leakage of the boiler tubes expanded into the flue sheet of the ordinary type of locomotive boiler, from the effects of expansion and contraction, by cold air drafts through the fire-door, holes in the fire on the grates, or by a badly-clinkered fire.

7th. A crown sheet supported by direct riveted over-staying to tee bars, these latter in turn being supported by adjustable stays, secured to the tee bars riveted to the outer shell, allowance being made for contraction and expansion, and to avoid undue stresses on all of the firebox sheets and stays, and subsequent fracturing.

8th. The crown sheet being located below the boiler tubes, there is practically no possibility of damage to this sheet or its staying on account of over-heating, through reason of low water.

9th. The fire-box and combustion flues being located at the lowest position in the boiler will, through their intense heat, promote the evolution at this point and prevent the precipitation of the corrosive and other mineral ingredients contained in the feed water and the consequent pitting action on the sheets which usually occurs in the parts of the boilers which are at a relatively low temperature.

10th. A construction of boiler with a simple combustion chamber that will not only permit of the superheating of the steam by the furnace gases when they are of an intense temperature, and which is necessary for this purpose, but which will, in addition, allow of the use of long tubes, both points of which should receive every consideration for the reason that they are necessary for and productive of efficiency and economy.

11th. A smoke box, with no complicated draft arrangements, combined with a large diameter of smoke stack, for the unrestricted passage of gases.

Referring now to the boiler as regards maintenance:—

1st. An arrangement which will facilitate inspection, testing, washing-out and the removal of the foreign matter necessary to keep all the parts in good repair and in a clean condition to conduct the greatest amount of heat.

2nd. An arrangement of combustion chamber and smoke box which provides easy access to make repairs and renewals to the combustion flues, the boiler tubes and the tube sheets, which are the parts that receive the greatest stresses and require the most frequent attention.

3rd. The spacing of the tee bars and the stays to the crown sheet to be such as will allow for the ready cleaning and washing of the crown sheet without the removal of any of its attached parts.

4th. An arrangement of boiler tubes, the removal of which alone will give every opportunity to inspect, clean or renew the crown sheet and its stays, which is not practicable with the present type of boiler construction.

5th. There being from one-half to two-thirds less of the smaller tubes than as found in the ordinary type of boiler, the care and expense for the usual cleaning and re-setting will be greatly reduced.

6th. A proportion of furnace fire and cross-sectional combustion flue and boiler tube draft area which will permit of free draft and less liability of the passages to become inefficient on account of choking or neglect of attention when restricted by an accumulation of foreign matter, and the larger passages will reduce the amount of cleaning now necessary.