The effective work of the steam now having been completed, it will be released at a back pressure of from 2½ to 3 lbs. through an 8-inch diameter large capacity exhaust pipe, and conveyed for further use in heating, and for condensation to make boiler feed water.

Thus it will be noted that a pound of steam from the boiler at 250 lbs. indicated initial pressure of 406.17 temperature, and containing 1,205.8 heat units, has been expanded 12 volumes, and reduced, after having performed effective service on the pistons to operate the locomotive, to a terminal pressure of 6 lbs. of 230.55° temperature, and containing 1,152.3 heat units. This, as compared with a pound of steam of 200 lbs. indicated boiler pressure of 387.88° temperature and containing 1,200.2 heat units, being expanded about four volumes to a terminal pressure of 45 lbs., containing 292.5° temperature and 1,171.2 heat units, and at which point it is exhausted into the atmosphere, shows 53.5 as against 29 heat units contained in the same given quantity of steam which are used to perform effective work in the cylinders.

Deducting the 5.6 heat units that we originally required to increase the steam of 200 to 250 lbs. pressure, we have an actual increase of 18.9 heat units used to produce power in the cylinders, which is 65% more than the total heat units converted into useful energy in the single expansion cylinder.

In the above, no consideration has been given to the additional results which will come from superheating and the use of the exhaust steam for feed water heating.

The steam having been delivered at the water tank, now finds its way through two three-inch conduits, designated by letters KK' on the drawing, one each leading to the right and to the left hot feed storages, and the additional steam which cannot pass to these chambers without increasing the back pressure to more than 2½ lbs. is relieved into the lower portion of the central condenser passage, indicated by letter F. The steam being conducted to the rear of the tank through this passage, it returns through the central passage, designated by letter F", to the front of the tender, from which it is conveyed to the right or left steam spaces, designated by letter G, where it comes in direct contact with the cold feed storage. After having had an opportunity to condense during its travel through the tender, the steam is now relieved to the atmosphere in the form of a vapor, from the 8-inch diameter relief opening at the left back corner of the water tank, and which relief will prevent any back pressure in the tank or in the cylinders.

Should it be possible to utilize the heat contained in the steam which will be exhausted into and partially condensed in the water tank and condenser, to increase the feed water of an average temperature of 60° to 212°, or boiling point, the total heat units used to advantage would then be 105.6, or what was required to first generate the steam.

This, however, would not be practicable in locomotive service for reason of the losses which will come about through radiation and the inadequate means for condensing aad absorbing the heat contained in the waste steam.

However, as 1 lb. of steam, at the minimum exhaust, or 2½ lbs. pressure and at a temperature of 220° Fahr., containing 1,149 heat units, will heat to 212° temperature, or boiling point, 7.52 lbs. of water from 60° temperature, it will be readily understood of what advantage the use of the exhaust or waste steam will be, more especially during the colder and more severe atmospheric conditions, to store heat into the feed water preparatory to its being injected into the boiler, and it will be practicable to utilize, through the use of the steam as is proposed, at least 50% of the heat now being generated and wasted.

Presuming that during the time the locomotive has been operated with the steam distribution as above referred to, it has been running at a rate of speed of 35 miles per hour, at which adjustment it is proposed that this locomotive do the greatest proportion of its work, the tractive power developed will be about 18,060 lbs., the indicated horse-power approximately 1,694, and the hauling capacity 1,840 net tons of cars, with lading, on level, straight track, under ordinary weather conditions.

It is from this practical use of the heat energy which must come from the fuel which is consumed in the proposed type of boiler, that will be utilized the greater proportion of the heat units contained in and absorbed by the steam during its passage from the boiler to the atmosphere, as compared with the use of an exceedingly small proportion of the heat units utilized from the steam used in the average American type of locomotive, and at the same time the amount of work that will be performed as regards the draw-bar pull, has been an increased efficiency.

THE TENDER WATER TANK AND CONDENSER CONSTRUCTION AND OPERATION.

The tender will have the same type of under framing and running gear, with connections, as the ordinary American type with swivel truck. The usual coal and water tank will be substituted by a hot and cold water feed storage and a heater and condenser arrangement. The tank will be of a simple and durable construction, compartments sub-dividing the interior taking the place of the usual coal space sheets, splash plates and stays, and making no more complication or expense for first cost or maintenance. The water hole will be located at the front instead of the rear end, where it will be more convenient to the fireman than as at the present. A walkway will be placed centrally with and on the roof of the tank for the convenience of trainmen going to and from the locomotive to the train; also a rear end centrally located ladder and signal lamps arranged as on the present type of tenders.

Referring to the drawing of the tender tank, the sub-divisions are indicated by the letters, and the arrangement for the operation is as follows:

Presuming that the tank is empty, it will be filled through the water hole I, which is located on the flat deck at the head end; this waterhole being of ample dimensions, especially in width, so that the stand pipe spout can be more readily adjusted if the water hole is not stopped exactly opposite the stand pipe. If the water service requires that this tank be arranged with scoops it can be done.

The right and left hot feed water compartments, designated by DD', are equalized with each other by the six inch pipe N, and connected to the cold storage E by the 2½ in. inlet openings OO' located with the lower edge one inch from the tank bottom, and which will admit water from the cold to the hot storage in about the same proportion as it will be used, and maintain an equalization of the level. The hot feed compartments DD' will extend beyond the rear of the flat deck, in order to permit of opportunity for inspection, cleaning and repairs; also to permit of the more prompt filling of these wells when the tender is being filled, by an overflow of the water over the top of the partition when the cold storage tank is full, and from the surface where the water in the cold storage will be the most heated. This arrangement will also permit of a direct contact of the hot feed water with the exhaust steam, which will be confined in the space G when the locomotive is in operation, and will also relieve these compartments of any excess steam when the water is low in the tender.

The hot and cold water compartments now filled, on the starting of the blower turbines, air pump, stokers and water pumps, the exhausts from each being connected to the main cylinder exhaust pipe S leading to the tender, and the outlet S' of this pipe being retained closed by a gravity seating 8 in. diameter valve until the pressure of 2½ lbs., which is equivalent to ½ lb. more than the weight of the water of the greatest depth above the outlets to the auxiliary exhaust steam inlets KK' has accumulated, these exhausts will be conveyed into the hot wells direct. This arrangement will permit of the most constant possible induction of steam into these hot wells at all times.

The locomotive now being started, such a part of the released cylinder steam will also be conveyed through the pipes KK' direct to the hot wells as a back pressure of 2½ lbs. will convey through these outlets, and when the water in the tank becomes low, the excess steam will be relieved through the hot well into the cold storage through the opening V. The cylinder exhaust steam having reached a back pressure of 2½ lbs., will force the valve S' off its seat, and the main portion of the exhaust will pass into the lower compartment F of the central condenser space, partially condensing itself and heating the cold feed water on either side through its contact with the compartment plates. The steam now passes through this compartment to the rear of the tank, then up and forward through the upper compartment F" of the central condenser, the condensation at this point being relieved into the lower compartment, at the steam inlet opening F'. The steam is then relieved through four 6 in. openings W in the left and eight 6 in. openings W in the right condenser space side sheets, located centrally between the maximum water level and the top of the tank roof, into the steam space G which is of large volume, where it will come in contact with the surface of all of the feed water level. This space is relieved by an 8 in. exhaust pipe H, located at the left rear corner of the tender, where the escaping vapor during the severe weather will not obstruct the engineer's view to the rear of the train. The accumulation of water in the lower condenser compartment F can be readily relieved by closing the tank valve J' and opening the drain valve U, which makes a direct connection from the condenser space to the left-hand feed pump to the boiler. The lubricating oil which will find its way with the exhaust steam into these water compartments will not be of a sufficient amount to cause any bad effect in the boiler, and there will be little liability of any passing through the feed outlets JJ', which will be located in the bottom of the tank, as the oil will always remain at the highest water level, and can periodically be removed. However, should this oil be found detrimental, a skimming arrangement can be applied which will overcome any difficulty through this source.

It will be noted that the exhaust steam inlet pipes KK' to the hot feeds have rounded off conical mouthpieces, these being the most efficient for the efflux of steam, and they are located close to the outlets for the boiler feeds JJ'. This is arranged to keep the water at the outlet heated to the highest possible temperature, also to keep up an agitation at this point, which will cause the precipitation of foreign matter from the heated water to seek a more quiet location in the mud basin at the rear of the tank valve cisterns QQ' at the rear of the hot feed wells, from where it can be removed periodically by suitable connections Q" instead of finding its way into the boiler.

A water hose connection to the pipes Q" at the outer edge of the hot well, and the removal of the mud plugs Q" will facilitate the ready removal of all such accumulations of sludge.

A two-inch pipe connection will also be arranged from the boiler to the main exhaust