does not consider the savings that can be further effected through the other means enumerated, which are, compounding, heating of the feed water, higher initial and lower terminal pressure, superheating, reduced cylinder clearance, reduced loss of unconsumed fuel, the use of steam water pumps instead of injectors, cheaper and inferior grades of coal, elimination of incrustation and radiation, etc. Therefore the statement made with reference to the 60% reduction in the cost for fuel can be safely considered as a practically reliable minimum estimate.

Considering next the cost of water being 0.33 of a cent per mile run, this will be reduced at the least 20%, for the reason of the cross-compounding features, superheating, condensation of the exhaust steam from the low pressure cylinder, air pump, water pumps, steam turbines, automatic stokers and other exhausts, reduced liability for waste through leakage on account of the constructive features of the boiler, reduced piston speed and less slipping through the greater adhesion on the drivers by the additional weight of the coal storage over the boiler. This reduction of 0.066 of a cent will reduce the total figure for water to .264 of a cent, as compared with .33 of a cent.

With reference to the cost for sand and supplies, the increase of adhesive power owing to the storage of the fuel over the driver wheel base, should with the tractive power given, reduce the slipping effect to the minimum, and this cost can be reduced 50%, or to .045 of a cent.

As regards lubrication and waste, the operation of the additional steam cylinders of the water pump and turbine, the bearings for the blower for the mechanical forced draft, and the steam cylinder and operating gear for the automatic stokers, together with the higher initial steam pressure, will probably increase this cost to exceed not more than 25%, or .06 of a cent, making the total cost .31, as compared with .25 of a cent.

These figures for the operation give a total of 11.7 cents, as compared with 19.79 cents, or a reduction of 8.09 cents, or 40% per locomotive mile run, the wages of the engineer and fireman remaining a constant quantity, and having been considered in these figures at a disadvantage to the proposed service in the comparison.

As regards the maintenance, presuming that the cost for the general shop, the running repairs, and the handling at the roundhouse, per locomotive mile run, not including any charge for supervision or the use of shop tools and machinery, is as follows: Repairs to machinery and boiler per locomotive mile run, 3.77 cents; washing out, cleaning and despatching, per mile run, .88 of a cent., or a total of 4.65 cents.

In the proposed type the extra equipment required in addition to or to replace equipment now in use on the present type of locomotives is as follows:—

MACHINERY.

Device.	To Replace.
Cross-compound cylinders and operating gear.	Single expansion cylinders and operating gear.
Two water pumps and connections.	Two injectors and connections.
Driver spring compensating gear.	Extra.
Exhaust conduit from the low pressure cylinder to the tank.	Extra.

BOILER.

Two blowers and steam turbines, with blast pipes and gates, and connections.	Exhaust nozzle stand pipe and tip and connections, smokebox netting, draft arrangements, cinder hopper and hand-hole plates.
One 13 ft. x 24 in. x .500 in. gauge corrugated flue, two 13 ft. x 12 in. x .375 in. gauge corrugated flues, two 13 ft. x 6 in. x .250 in. gauge plain flues, and two 13 ft. x 5 in. x .250 in. gauge plain flues.	Extra.
$\frac{135}{138}$ ft. 6 in. x $2\frac{1}{2}$ in. x .135 in. gauge boiler tubes.	$\frac{3}{16}$" ft. x 2 in. x .125 gauge boiler tubes.
One smokebox, door and front.	Extra.
One combustion chamber.	One extended smokebox.
Three automatic stokers and operating gear.	Rocking grates and gear.
Stoker blast retort.	Front section of ash pan, dampers and rigging.
Coal tank and cover.	Coal space sheets, gates, etc., and tender tank.
Stoker hopper coal conduit.	Extra.

TANK.

Exhaust steam inlet connections to the condenser and hot feed space.	Extra.
Condenser drain valve and pipe.	Extra.
Compartment plates.	Splash and stay plates.

By noting the above, it will be seen that while some of the new and special equipment will replace equipment which is now in use, at the same time the cost for this locomotive, complete, as compared with the present American type of the same haulage capacity, will be about 15% more. The other arrangements will be practically the same, excepting the minor alterations which will have to be made to suit the conditions. While the construction of the additional mechanism will be durable and one which can be easily maintained, it will, however, require overhauling each time the locomotive goes into the shop for general repairs. The extra cost involved to maintain it can be safely placed at not to exceed 10%.

Considering the boiler construction, this is such that in consideration of the lesser stresses to which it will be subjected, it being more flexible to adapt itself to expansive and contractive influences, the reduced water joints and seams in contact with the intense furnace heat, and on account of the arrangement of the flues, boiler tubes and crown sheet, the reduced cost for maintenance should not be less than 20%. This reduction will, practically, over-balance the increase for machinery repairs, and the total cost for maintenance will remain the same.

The cost for washing out, cleaning and handling at terminals, on account of the reduced amount of fuel to be supplied, the easy method for and the less cleaning to do of the fire and ash pan, the use of condensed and hot feed water preventing an accumulation of scale and foam producing matter in the boiler and less washing out required, the larger tubes being less liable to choke and easily cleaned when required, convenience to fire up, and but few more surfaces to keep clean, should be reduced, as an estimate, about 10%. This reduction will amount to .088 of a cent per mile run, or make a total cost of .79 of a cent, as compared with .88 of a cent.

The cost for fuel for firing up will also be reduced, as the blower turbine can be connected to the roundhouse steam pipe, which will promptly provide the draft to promote the firing up of the coal in the stokers with a very small amount of kindling or fuel oil; and one stoker fired, a few live coals taken from it and supplied to the others will suffice to fire all, and with no resulting additional loss of unconsumed fuel from the grates, as is now the case, or the suction of a large amount of cold air through the boiler tubes to produce the excessive expansion of the sheets that is caused by the present arrangement of induced current with the steam blower.

As compared with the present total cost for this service, and by permitting the engineer's and fireman's wages, which are about 23% of the total, and which remain a constant quantity, to figure in, the total cost for operation and maintenance will be 16.26 cents, which is a reduction of 8.18 cents, or 33½%. These figures which have been taken are from a practical and theoretical basis, considerably below the margin, and may be relied upon to be forthcoming in actual practice.

THE OPERATION AND MAINTENANCE OF MOTIVE POWER IN THROUGH FREIGHT SERVICE.

While in the following remarks the unfavorable conditions in the more severe weather districts have been kept in mind, the general ideas may, however, be considered as applicable to the more favorable climatic localities as well.

In the design and construction of power, too much attention cannot be given to the interchangeability of the parts of all types, that the least number of metals, patterns for castings, and forgings will be required for the general shop stock, and to be kept on hand at the roundhouse points for emergency repairs. It is of decided advantage to have extra finished parts on hand at all roundhouse repair stations, that can replace the parts of the machinery which are most liable to failure from wear and running service, and thereby prevent unnecessary detention of the power from service.

Simplicity and interchangeability of design should be adhered to, and patented devices and fads which have no actual practical value should be eliminated.

A type of locomotive having been provided adapted for the service required, the methods for its successful handling over the district or division should receive the next consideration. Therefore, to further increase the efficiency and the economical operation and maintenance of motive power, the following recommendations are submitted:—

Each locomotive, after it has given such an amount of service as will justify heavy repairs, or providing the condition otherwise warrants it, should receive a thorough overhauling when it is taken into the general repair shop.

On many systems is found the practice in vogue, and which is encouraged, to stimulate by competitive methods between the various shops, a large monthly output of locomotives, due consideration not being given in making the comparisons, to the class of the repairs made, or which should have been made, to put the locomotive in a thoroughly serviceable condition.

Correct records kept of the dates and classifications of repairs, together with intelligent inspections, and work reports from the engineers and road and roundhouse foremen to whom the locomotives may be assigned, will determine the class of repairs required to each locomotive as it goes into the shop, and the work so specified, and what additional may be found necessary by the shop inspectors, should receive every consideration from the shop authorities. The proper place to make heavy repairs to power is at the general shop, where facilities for handling this class of work the most economically are provided, and much relief will be given to the roundhouse expense, and detention of the power from service, if the work is cared for as above mentioned.

The tendency to make repair shops of roundhouse terminals should be discouraged, and this evil can be eliminated only by performing first class work at the general shop.

A locomotive turned out for road service after having received a first-class overhauling and a thorough test, will soon assert its condition by efficient, economical and continuous service, when properly operated.

But no matter how efficient a condition a locomotive may be put in, it will not remain in good repair unless it is given constant attention by a competent roundhouse organization.

If the service and the cost for the maintenance, operation and shop repairs of a locomotive which has received thorough attention and enters the general shop in the average condition, due to wear and tear, after having made a satisfactory mileage since its last shopping, is compared with one that did not receive the