short of the wheels, and thus being free from side control are made three or four feet wider than rail gauge. The length of grate has in powerful freight (goods) engines reached a maximum of 11½ feet, necessitating an intermediate support for the water tubes and movable solid bars.

An equal and perfect distribution of the total weights available for adhesion on the coupled driving wheels is possible when the fire-box is made so shallow as not to come within the frames in a manner rarely obtained when deep fire-box is used, as it often outwardly controls the relative position of the coupled axles.

A further constructive peculiarity caused by the width of the fire-box, is that instead of springs being placed directly over or under axle-boxes, and the spring ends connected by compensating or equalizing levers, deep narrow levers are passed over and bear upon the axle boxes, and the lever ends are coupled to the springs, or, in other words, the springs lie horizontally between and about in line with the axles, instead of above or below them. So arranged, the engine rides smoothly and easily.

To sustain the weight at rear end of boiler, the fire-box is carried upon four massive reversed pendulum links from lower part of engine bar-frame, which, without limiting the expansion and freedom of movement longitudinally holds it in designed position firmly.

Shallow depth of fire-box, being, as hereafter explained, a necessity of economic combustion, it is obtained by quickly sloping downwards from tube sheet the crown plate of inside fire-box, so that at the back the effective depth of box is but about 2 feet 8 inches, and not only is the inside crown inclined, but, to avoid excessive weight and keep centre of gravity low, the outer crown is also sloped longitudinally and the two sheets secured together by screwed rod stays ; thus anticipating that form of crown sheet known under the name of its Continental patentee "Belpaire." The distance apart of the two crown plates much increases as they come towards the barrel, thus providing freer circulation.

The firing is done from tender, and necessarily the fire hole is of rather more than ordinary width to give freedom of firing over so large a surface, and it is quite close to crown sheet, so as to give with shallow fire-box 14 in. to 16 in. depth of fire on grate without fuel standing above the level of fire hole. The so-called "Combustion Chamber," occasionally provided forward of fire-box, is not to secure more perfect combustion, but is due to the grate being so high that a bridge is necessary to keep fuel on sloping grate, from travelling bodily into and choking the boiler tubes, and, space being required forward of bridge, so that passage be left for gases to enter the lower tubes, the chamber or partial extension of fire-box into barrel becomes a necessity, although it has the defect of shortening the boiler tubes by its own length.

The shallow fire-box secured in part by sloping grate up, and crown sheet down, and used certainly as early as 1848 9, is not only a convenience in constructive design, but for effective combustion a necessity, as this fuel, due to the absence of hydrogen, is only slightly inflammable, when burnt openly and freely, and to secure as much flame and as large a portion of radient heat as possible, an artificial current that will lift the fine incandescent particles and keep them in suspended motion and contact with the hot gases is desired. This lifting and suspension, the exhaust blast with shallow fire-box and large grate surface accomplishes, securing a full body of short, light-coloured flame, and therefore securing radient heat : and the crown sheet—the best absorbing surface—being close to the flame, is made the more effective. A close parallel can here be drawn between the behaviour of Anthracite in a reheating and in a puddling furnace. In the latter, with the same air pressure and grate surface serviceable flame cannot be obtained ; whereas, with no other change than a low roof, the reheating furnace produces a white flame and intense radiant heat, bring the iron up to a welding heat rapidly and economically.

The P. & R. R.—a large user of this fuel—give me as the result of their experience with locomotives, that one pound of Anthracite evaporates 6.1 pounds of water, and one pound of Bituminous 7 pounds of water, under similar and average conditions of railway work—in other words, Anthracite has an evaporative efficiency of .87 per cwt., and Bituminous of 1.14 per cent.—in each case taking the other fuel as the unit of comparison. With their market prices at tidewater as in June, Anthracite per gross ton at $3 50 (14 shillings), and Bituminous at $3.05 (12 shillings), the cost of evaporating one pound of water is, Anthracite, .0255 of a cent, and Bituminous .0194 ; thus Anthracite has an *economy* efficiency of .76 per cent., and Bituminous of 1.31 per cent., in each case the other fuel being taken as the unit of comparison.

The Pennsylvania Railway gives me the consumption in pounds of coal per passenger car mile for four months under conditions so similar as to make a reliable comparison. The market value of coal being, Bituminous per net ton $2.73 and Anthracite $3.82 per gross ton, or per 100 lbs. Bituminous costs $13.65 cts. and Anthracite $17.05 cts. Anthracite being per pound fully 25 per cent. the dearer fuel.

On *Local* passenger runs the consumption per passenger car mile was 10.44 lbs of Bituminous against 13.85 lbs. of Anthracite—a difference of 3 41 lbs., their relative percentage values (comparison as before) being 1.32 per cent. and .76 per cent. or multiplying the amount by the cost, the items stand in cents per car mile 1.425 for Bituminous and 2.363 for Anthracite, a difference of .938 cts., their relative economy percentages being 1.66 per ct. and .60 per ct.

For the same period on through or continuous passenger train runs the figures in pounds per car mile are 8.64 Bituminous against 11.55 per Anthracite, a difference of 2.91 lbs. their relative evaporative percentages being 1.25 per cent. and .80 per cent., on multiplying this weight by the cost, the expense per car mile in cents is 1.179 for Bituminous and 1.969 for Anthracite, a difference of .79 cents per car mile ; thus their relative economic percentages are 1.67 per cent. and .59 per cent.

The through run with but few stops and making continuous demands on the full uses per car mile, 1.80 lbs. less of Bituminous and 2.30 lbs of Anthracite, but as these differences bear to each other the percentage proportions of 1.27 per cent. and .80 per cent., it seems as if Anthrcaite could be used as advantageously where the stops are frequent as in through runs under ordinary conditions. Although it is Mr. Wooten's opinion, that where stops are frequent, or work intermittent and the maximum power is called immediately after such intermission less Bituminous coal need be used because of its ready ignition.

The reason of Anthracite having a less evaporative efficiency is in part due to its density, the heat of combustion being greater in proportion as molecular condensation of fuel is less advanced—the better control permissible through the air dampers of the combustion of fuel possessing free carbon or volatile gases, and to the large mass of fuel on grates at the end of each trip which cannot be utilized ; also as a depth of 14 in. to 16 in. of live coal is kept on the grate, it is highly probable (although I have not been able to test and prove it by