Two Engines for One

By Herbert T. Walker

WITH the constant increase in the cost of labor, fuel and all material, it has become necessary to utilize every pound of draw-bar pull the locomotive engine is capable of. Until recent years, the tender of a locomotive has been a paying load only in so far as it has served to keep the engine supplied with coal and water; but beyond this it has been a dead weight, and, as many tenders weigh about 175,000 pounds, this is now a serious consideration.

The management of the Southern Railway has been contending with the problem of operating a line having an unusual amount of curvatures and heavy grades, one representing a continuous ascending grade of four per cent for a distance of three miles. A solution of the difficulty has been reached, after much experimental work, by utilizing the cylinders, frames and running gear of old mogul and consolidation locomotives withdrawn from service, and placing them under the tenders of the regular Mikado type of road engines in use on that line.

The first of these "duplex" engines made its initial trip in March, 1915, and since that time a large number of them have been put in service with highly satisfactory results. It appears that the tax on the steam supply from the boiler of the main engine is not excessive, since the duplex engines operate over rolling grades, permitting the steam tender to run idle as opportunity offers. Furthermore, it is found that with the addition of fire-brick arches, feed-water heaters and other improvements to the main engine, there is ample steaming capacity to supply all four cylinders through a period of 50 minutes. By careful research it has been demonstrated that by the use of the steam tender the hauling capacity of a locomotive so equipped is materially increased without complicating its design or in any way interfering with the comfort or convenience of its operators.

A very important feature in connection with this improvement is the fact that many light locomotives which, in the ordinary course would be relegated to the scrap heap, may now have the old boilers removed and the tanks of the standard engines mounted on the old locomotive frames, utilizing the entire engine to get the increased tractive power at very small expense.

The accompanying photograph of one of these duplex engines will give a good idea of their appearance, and a line drawing of the steam tender is added to bring out interesting details.

The general dimensions are: Weight of engine, 367,000 pounds; cylinders, 28 inches diameter by 32 inches stroke; diameter of driving wheels, 57 inches; tractive effort, 71,100 pounds; weight of steam tender loaded, 253,000 pounds; cylinders, 19 inches diameter

by 26 inches stroke; diameter of driving wheels, 57 inches; tractive effort, 18,000 pounds; making a total tractive effort of 89,100 pounds for the duplex engine.

The main steam supply to the tender engine is by means of a 3-inch pipe connected to the header of the superheater and extended back along the boiler and under the cab where it is coupled to a pipe having flexible joints leading to the valve chests. To provide

exhaust steam is conducted by a 5-inch pipe to the rear of the tender. The reversing gear is of the Southern type, having a fixed link, which is giving general satisfaction on many lines.

These duplex locomotives have demonstrated that the gain derived from the tractive effort of the auxiliary engine, notwithstanding the reduction of main engine boiler pressure, amounts to more than 30 per

cent increase of tonnage over similar engines having the ordinary tenders.

Although it is not necessary to build new equipment to get the benefit of these improvements, advantage will be taken of the idea, and new engines will be built on the system under notice; that is to say, the tenders of standard "Mikado" locomotives will be fitted with the standard locomotive wheels and running gear for operating the tender at low speeds, thereby increasing the tonnage which can be hauled over heavy grades without the assistance of a helping engine.

For a conservative estimate of the gain derived from the use of duplex locomotives, we will assume that a steam tender has been attached to a modern freight engine using superheated steam at a boiler pressure of 175 pounds per square inch. This engine may develop an effectual tractive effort of 51,000 pounds which may be its maximum. Should steam be taken from the boiler to such an extent that the pressure is reduced to say 155 pounds, the tractive effort of the leading engine would then be reduced to 45,000 pounds; but during this reduction of pressure on the leading engine, the auxiliary engine has been using the steam from the boiler of the front engine and developing a tractive effort of about 18,000 pounds, so that the available locomotive power for hauling the train, while decreased for lack of steam in the front engine from 51,000 pounds to 45,000 pounds, is getting the advantage of, say, 18,000 pounds tractive power from the auxiliary engine, or a net increase in draw bar pull of about 12,800 pounds and it is due to this fact that fluctuations and reductions in the steam pressure of the front engine are much more than offset by the power derived from the auxiliary engine, making it possible to increase the train haul in certain districts where the grades are favorable about 30 per cent without materially increasing the cost for fuel, as the tender engine is only used for short periods at a time and but little additional firing is required.

Of course, steam tenders are not new, but the idea of utilizing the running gear of discarded locomotives seems to have originated with the mechanical officers of the Southern Railway. Locomotives with auxiliary power have been in use for some years, notably on the Erie Railroad, and some engines on the Virginian Railway are used with success. It is also of historical interest to know that

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Southern Railway duplex locomotive, in which the tender is carried on the under-body of an old engine, which contributes to the motive power of the assembly

How the Southern Railway steam tender is put together

An ancestor of the steam tender, used on the Great Northern Railway (of England) as early as 1865. This steam tender was especially built rather than assembled from discarded locomotive bodies

The Great Northern steam tender coupled up with its master engine. Like the present Southern Railway model, this auxiliary power plant got its steam from the boiler of the regular locomotive, which has a producing capacity greater than the consuming ability of its own cylinders

an additional supply of saturated steam when working on heavy grades, a small pipe is led from the boiler head to the 3-inch steam pipe. The throttle and auxiliary valves and the power reversing gear of the steam tender are independent of the same parts on the main locomotive and are all controlled from the cab by levers within easy reach of the engine driver. The

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Pooling Our Power

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4,000 horse-power in boiler equipment. Instead of those numerous, wasteful, dissipated plants, all of the essential power is furnished today by a single central electric station depending upon a boiler capacity of only 500 horse-power! Wire conductors have supplanted the erstwhile steam mains, and the diversified energy demands of the several properties are thus satisfactorily taken care of, and all because the power need at any one time does not exceed the central station's resources.

But it would not suffice if, in establishing a super-power zone, the railroads continued to depend upon the steam locomotive as a tractor. To obtain the greatest benefits, it would be necessary to electrify all of the trunk lines and those of the feeders where the density of traffic would warrant electric haulage. The steam locomotive is not an example of fuel economy, gaged by modern standards, and from the nature of its get-up this engine requires a pretty high grade of coal. Further, the locomotive must expend a considerable measure of its tractive effort in dragging along behind it a tender loaded with coal and water. Mr. Murray states that the steam passenger locomotive calls for 2 pounds of coal for each pound burned in energizing the electric locomotive; the steam freight engine is 1½ times more costly in the matter of fuel; and the yard or shifting locomotive when driven by steam consumes 4 pounds of coal against the one pound needed where equivalent energy is generated for the electric tractor. These data are based upon the records of a central power station, built some years ago, for the electrified section of one of our great eastern railways.

As originally equipped the plant had eight 5,000-kilowatt generators, and at that time the heat efficiency of the installation was 8 per cent. The nation is about to be modernized by substituting a single 40,000-kilowatt machine; and the efficiency should be quite 18 per cent! Therefore, the relative figures in the preceding paragraph should properly be correspondingly modified to the added credit of electric traction. It should cause no surprise, then, to be told that it is possible to provide all of the motive force needed within the proposed zone by a carefully coordinated plant capacity of 5,500,000 horse-power where we now have stationary and mobile steam plants totalling 17,000,000 horse-power! This would entail a yearly saving of fully 30,000,000 tons of coal, which, at \$5 a ton, would mean an annual economy of \$150,000,000.

Another prominent man in the engineering world, Mr. Edwin Ludlow, emphasizes the economic necessity of doing away with steam traction as far as practicable on our railways. As he explains: "The railroads now burn 28 per cent of the total output of the bituminous mines; with electrification this would be reduced to 10 or 12 per cent. Freight congestion and car-supply troubles also would be solved, as the central power plants in the coal-producing states could be located at a group of mines, requiring only a minimum of switching service. Coal too high in sulphur for safe service could then be burned as produced, and the mines kept in continuous operation."

Car-mileage service in the transportation of coal could, in this way, be enormously reduced, and the vehicles applied to the hauling of vast quantities of other freight—doing this without adding at all to track congestion. It is authoritatively stated that electric energy in blocks of quite 500,000 horse-power can be distributed over a radius of 300 miles from the source of generation. Heretofore, the "corona effect," induced by high-voltage on comparatively small copper conductors, has occasioned heavy losses on long lines

and, therefore, seriously curtailed commercial distribution of current. But by the substitution of cheaper and larger aluminum conductors this loss has been materially lessened and the zone of transmission widened.

Ultimately, the super-power plan embraces the establishment of monster electric generating stations at the mine mouth or within easy reach of the pits, and it will be entirely feasible to consume there grades of coal that are normally unmarketable and, of course, quite unsuited to burning under the boilers of steam locomotives. What is more, these master plants will require but a minimum of attendance owing to the mechanical facilities which will make the feeding of the fuel substantially automatic. Clearly, the carrying out of this revolutionary scheme of general electrification will greatly diminish the cost of machinery maintenance; and it would be possible to bring about a marked consolidation of trains through the greater effectiveness of the electric tractor. It is believed that these two departments of economy will lead to an additional yearly retrenchment of \$150,000,000 in the projected super-power zone, while speeding up our productive capacity, amplifying our passenger and freight transportation, and widening the ways in which electricity may serve our domestic comfort and convenience.

It is undeniably true that the initiation of the super-power plan would require very large outlays of capital, but the expenditures would be amortized in a few years; and once established the system would bring benefits in its train that are difficult to grasp and visualize in their entirety at the present time. It would effectually prevent a recurrence of the conditions that confronted us during the crucial period of our participation in the World War. The citizens of our Eastern States within the section in question do not know it generally, but we came precious close to an industrial collapse and a transportation stalling that might have provoked the very gravest of consequences. With a super-power zone called into being in our North Atlantic region, then kindred methods would be applied elsewhere throughout the country whenever circumstances warranted. Mr. Murray has shown how we may in the decades to come hope vastly to augment our productive activities while cutting down to an amazing extent our annual consumption of coal. Needless to remark, he contemplates, wherever possible, the fullest utilization of our waterpower resources.

Two Engines for One

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tractor tenders for freight engines were running on the Great Northern Railway (England) in the early sixties. The present writer saw many of these engines at work, and they attracted much notice, not only by the great length of their trains, but by the puffs of exhaust steam which issued from the rear of the tender.

These locomotives were designed by the late Mr. Archibald Sturrock, who, shortly before he died, presented the writer with photographs of his engines. Mr. Sturrock was locomotive superintendent of the Great Northern Railway for many years and introduced some noteworthy improvements in railway machinery. Among them he conceived the idea of utilizing the weight of the tender for traction, and built about fifty locomotives which carried cylinders and driving wheels in the tender frame. A photograph of a complete engine and a line drawing of one of the tenders are shown in the accompanying illustrations. The weight of the tenders loaded was about 57,000 pounds. The middle axle was cranked and driven by a pair of inside cylinders 12 inches diameter by 17 inches stroke. The wheels were 48 inches diam-

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Two Engines for One

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eter and were connected by outside coupling rods. Steam for the tender engine was drawn from the main engine boiler and was controlled by a separate throttle valve. It was conducted to the tender cylinders through a pipe (visible on the photograph) from the outside of the steam dome. In practice this pipe was found sufficiently flexible without the intervention of compensation joints. The valve gear was the ordinary Stephenson link-motion worked by a separate reversing lever on the tender. The exhaust steam was delivered into a tubular condenser which was surrounded by the water in the tank, and what remained uncondensed passed away through two short outlet pipes at the rear of the tender. These and other details are clearly shown in the drawing.

The tractive effort of these tenders was about 5,600 pounds. The engines to which they were attached were the ordinary English freight locomotives of the period, but their heating surface was slightly increased to supply the necessary steam to the tender cylinders. The leading dimensions of the engines were: Cylinders, 16 inches diameter by 24 inches stroke; driving wheels, 60 inches diameter; total heating surface, 1,082.26 square feet; weight in working order, 73,000 pounds.

The tractive effort of the engine was about 11,264 pounds, which, added to that of the tender, made a total drawbar pull of 16,864 pounds.

The hauling power of these steam tender locomotives was nearly double that of the ordinary engines of the same class; for on a level road they drew sixty loaded cars, while the latter could pull only thirty-five cars on the same track.

Although a mechanical success, they were in advance of their time, for the trains they hauled were too long to be handled with convenience, since the length exceeded that of the side tracks. Moreover, on down grades the longer trains were difficult to control with the inadequate braking power of fifty years ago. Another reason for their failure was that the tender caught the dust and grit from the engine, making the repair bills heavy.

Finally, the engine men complained that they had practically two engines to care for instead of one, and their disfavor doubtless contributed to the want of success of these tenders, which, as Zerah Colburn (a great authority on locomotive engineering) said, "deserve to be remembered as a contribution to the practice of auxiliary power."

The Romance of Invention—XIII

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war, either one of which was bigger than ordinary man size. For they wished the airplane development on the Signal Corps and for fourteen of the eighteen months of the war the Signal Corps not only attended to its business, put its own men over seas, bought and manufactured its own equipment, laid down telegraph and telephone and cable systems, kept the army in touch with itself and with this country and kept the situation in France in touch (through its own cable) with the Navy and the forces in England—but at the same time developed the airplane industry from nothing to an army of over a quarter of a million workers and from no plants at all to some of the biggest in the world, while doing such side-issue pieces of work as getting out the spruce and developing the Liberty motor.

All these activities came to a point in the office of the Chief Signal Officer. It is a small office, with a desk in it, a telephone or so, a couple of pictures—and that's all. There were no papers. General Squier didn't write any papers or letters during the war. He hadn't time, in the first place, and he didn't believe

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