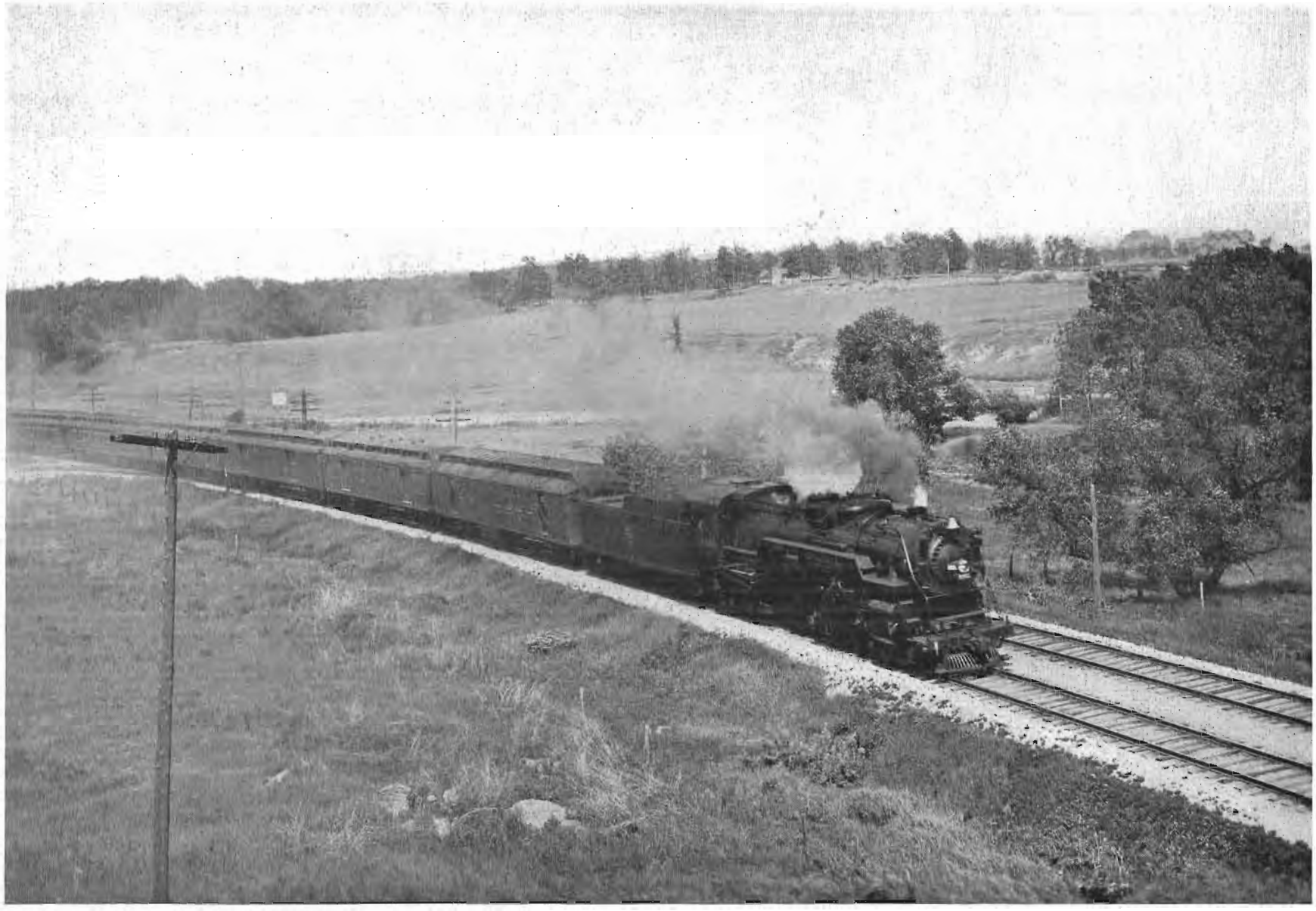


**A 4-6-4 Type Locomotive of Class F6 in Service on the Chicago, Milwaukee, St. Paul & Pacific Railroad**

The train is No. 17, *The Columbian,* and the view is near Milwaukee, Wisconsin.

# The Chicago, Milwaukee, St. Paul & Pacific Railroad

## A Brief Account of the Development and Operation of the System, with Special Reference to the Motive Power

By Paul T. Warner

It is a pleasure to acknowledge the courtesy of the Railroad Company in furnishing information and photographs for use in the preparation of this article, and extending courtesies to the author during a trip over the line.

Much of the information presented in the following pages has been obtained from the records of the Railroad Company and The Baldwin Locomotive Works, and from the files of the *Railway Age*. Historical data has also been secured from a book entitled "The Organization of the Chicago, Milwaukee & St. Paul Railway Company," by the late John W. Cary, published in 1891. The weights and dimensions of locomotives conform to the records of the Railroad Company, as far as such records are available.—Editor.

At the present time, when the central section of the United States is literally gridironed with railroads, and there are thousands of miles of line in operation in the Far West, it is difficult to realize that 80 years ago, with the exception of about 100 miles of line in Illinois, there was but one railroad in the vast expanse between Lake Michigan, the lower Mississippi and the Pacific Coast. The railroad referred to was the Milwaukee & Waukesha, a line which formed the nucleus of the present Chicago, Milwaukee, St. Paul & Pacific Railroad System.

It was in 1847 that the Territorial Government of Wisconsin chartered the Milwaukee & Waukesha Railroad Company to build a line between the two towns named. On November 23 of the same year, the commissioners named in the charter met in Milwaukee and elected a President and a Secretary; and a Board of Directors was elected on May 19, 1849. In 1850, the name of the corporation was changed to Milwaukee & Mississippi Railroad Company, and in February, 1851, the line was completed to Waukesha, 20 miles from Milwaukee. It was subsequently extended, reaching Prairie du Chien, on the Mississippi River, in 1856.

On June 3 of the year just mentioned, Congress made its first land grant to Wisconsin in the aid of the railroads, and railroad construction was stimulated in consequence. Wisconsin had been admitted to the Union as a State in 1848. The Milwaukee & Mississippi Railroad Company, in order to increase its mileage, purchased or leased a number of new roads, and by 1859 had in operation 234 miles of line. In that year, the Company made default in payment of its interest, a foreclosure took place, and a new corporation was formed under the name of Milwaukee & Prairie du Chien Railway Company, which succeeded to all the rights and property of the former Company.

The first annual report of the Milwaukee & Prairie du Chien Railway Company showed that, during the year ending December 31, 1861, a total of 37,175,350 ton-miles of freight were handled, and 130,183 passengers were carried. Of the latter, 120,672 were designated as "way," and 9511 as "through." The average distance traveled per passenger was 59 miles.

On May 5, 1863, the Milwaukee & St. Paul Railway Company was organized, and it took over the property of the Milwaukee & Prairie du Chien Railway Company. By the end of 1867, during which year the line reached the "Twin Cities" of St. Paul and Minneapolis, the Milwaukee & St. Paul Railway Company owned and operated 835 miles of road.

In 1870, the Company determined to construct a line from Milwaukee to Chicago. Up to that time it had entry into the latter city over the tracks of another line.

In 1871, the Wisconsin Union Railroad Company obtained a permit to build from Milwaukee south to the State Line, and in the following year, the Chicago, Milwaukee & St. Paul Railway Company of Illinois, was organized to build from Chicago north to the State Line. These roads, on January 1, 1873, were transferred to the Milwaukee & St. Paul Railway Company, and in the spring of that year the new line between Chicago and Milwaukee was placed in operation.

On February 7, 1874, by vote of the stockholders, the name of the corporation was changed to Chicago, Milwaukee & St. Paul Railway Company. This was during a period of severe business depression, as the entire country was suffering in consequence of the financial panic of 1873; but with the subsequent recovery from the effects of the crash, the road entered upon a policy of steady expansion. A new warehouse and extensive new shops were built in Milwaukee in 1878. On March 1, 1880, an agreement was completed with the St. Paul Union Depot Company for the joint use of the passenger depot at that point, with other companies. In the same year the road entered into an agreement with three other railroads—the Chicago & Alton, the Chicago, Burlington & Quincy, and the Pennsylvania—for the construction of a union station in the city of Chicago.

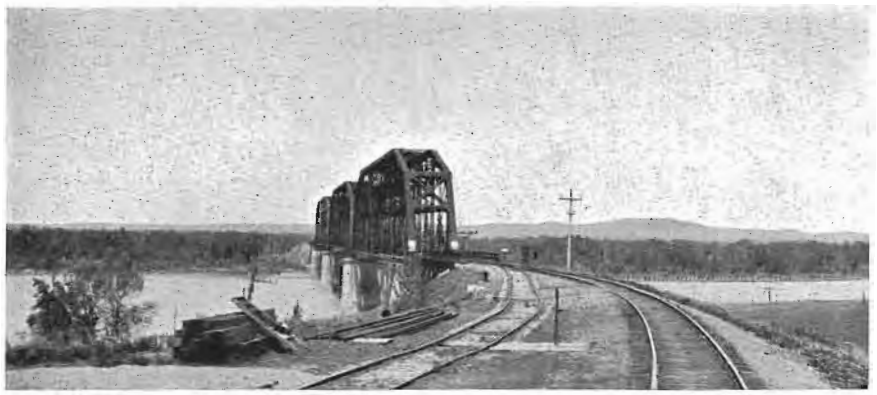
While these developments were taking place, new railroad construction was active. The completion of the so-called "short line," connecting St. Paul and Minneapolis, reduced the distance between the two cities to approximately ten miles and involved the building of a new bridge across the Mississippi River. Extension in the Central West was also being pushed, and the line was completed to Council Bluffs, Iowa, in 1882. Extensions westward from La Crosse, Wisconsin, through southern Minnesota and South Dakota, and westward from Minneapolis toward the Missouri River, were also under way.

Previous to 1882 the Company owned all its sleeping cars. In that year, a contract was made with George M. Pullman, whereby a one-fourth interest in the sleeping cars then owned by the Company was transferred to the Pullman Company. The latter Company agreed to conduct the sleeping car business for the railroad, which owned three-fourths of the equipment. After paying the expenses of operation, profits were to be divided between the two Companies in proportion to their respective interests in the business. This arrangement continued in effect until September 30, 1890, when the Railway Company exercised its option, reserved in the agreement, of canceling the contract and resuming full control of the sleeping car business.

The line to Kansas City, Missouri, was completed in 1887. Its construction included the building of an iron bridge across the Missouri River at Randolph Bluffs, a short distance below Kansas City. A permanent contract was made with the Kansas City Belt Railroad whereby the Milwaukee road secured right-of-way and entrance to the Union Depot and Stock Yards. Another important line, completed during the same year, was that extending from Manilla, Iowa, on the Council Bluffs Division, to Sioux City in the same State.

On June 30, 1891, the Chicago, Milwaukee & St. Paul Railway Company owned 6083.65 miles of line, located in the States of Wisconsin, Illinois, Iowa, Minnesota, North Dakota, South Dakota, Missouri and Michigan. The organization included a total of 105 subsidiaries, which had, at various times, been purchased or leased by the Company. Further extensions into the Black Hills, and in the region lying west of the Twin Cities, were planned and subsequently carried out.

At the beginning of the present century, the Chicago, Milwaukee & St. Paul Railway constituted one of the most important systems in the Middle West, rendering high-class service to a well-developed and most productive section of the United States. It was, however, somewhat handicapped by reason of comparatively short freight hauls, and the difficulty of obtaining its share of through traffic from connecting lines. The longest through freight haul, via either the Minnesota Transfer or the Omaha or Kansas City Gateways, was less than 500 miles. The line extending westward from Minneapolis, which terminated at Evarts, South Dakota, a few miles east of the Missouri River, penetrated a section of country in which comparatively



The Missouri River Bridge at Mobridge

little traffic originated. It was natural, therefore, that consideration should be given to the question of extending the line westward to the Pacific Coast; and in November, 1905, this extension was authorized.

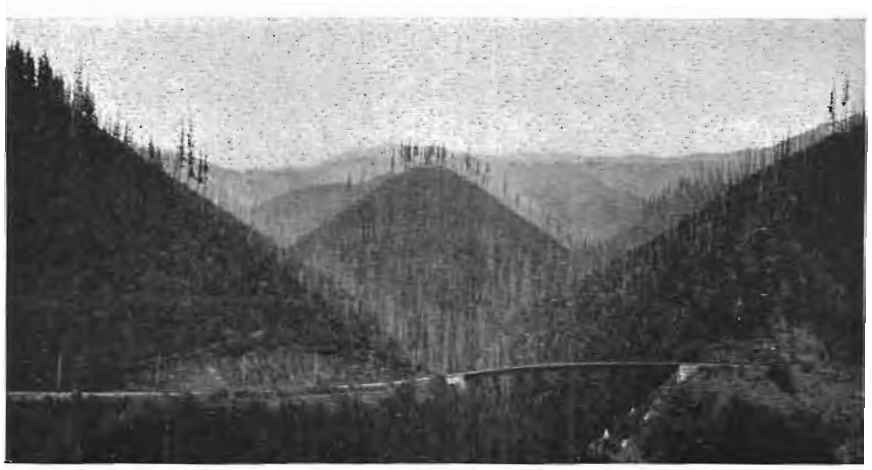
This was a bold step, involving, as it did, a heavy financial expenditure and the solution of many difficult engineering problems. Much of the country was undeveloped, and the line would have to cross five mountain ranges—the Big Belt Mountains and the Rockies in Montana, the Bitter Root Mountains in Montana and Idaho, and the Saddle Mountains and the Cascades in Washington. The construction of approximately 1400 miles of line was involved.

In April, 1906, construction was started, and was prosecuted along the entire right-of-way between the Missouri River crossing near Glenham, and Butte, Montana, a distance of over 700 miles. The Missouri River was spanned by a steel truss bridge of noble proportions, and the division terminal established on the east bank of the river was appropriately named Mobridge. The line was opened for freight and passenger operation to Butte, on August 30, 1908. Up to the close of that year, excellent progress had been made along the entire right-of-way to the Coast, but various gaps in the line remained to be filled in, and some of the tunnel work was proving difficult. Even at that comparatively early date, the question of electrifying the mountain divisions of the extension was receiving consideration.

By the middle of 1909, the gaps in the line had been closed and the road was opened for through freight service on July 4. The operating results for the first year were regarded as satisfactory. During the eleven months ending June 30, 1910, the extension carried 1,500,000 tons of revenue freight, of which 29.76 per cent was products of lumber and 21.44 per cent miscellaneous manufactured products. Products of mines furnished only 16.41 per cent of the total tonnage. The average haul per ton of revenue freight was 596 miles, which was unusually long, and indicated that comparatively little local business was handled.

During the second year of operation, ending June 30, 1911, the tons of revenue freight carried on the extension amounted to 2,450,000, of which 42.61 per cent consisted of lumber products.

An important piece of work, carried out during the years 1913 and 1914, was the construction of the Snoqualmie Tunnel in the Cascade Mountains, at an elevation of 2564 feet. The original line crossed the summit at a considerably higher elevation,



**In the Heart of the Bitter Root Mountains**

This photograph was taken from the eastbound *Olympian*, which, a short time before, had passed over the track seen on the opposite side of the valley.

Typical Scenery in the Cascades

with maximum grades of 2.2 per cent on the east slope and 2.75 per cent on the west slope. The tunnel, which was 11,890 feet long, saved approximately 3.6 miles of line, a rise and fall of 443.5 feet, and 1239 degrees of curvature.

Many timber trestle bridges were included in the Pacific Coast extension as originally built, but these were largely replaced, as soon as possible, with steel structures or embankments. For a new road, the construction work throughout was unusually substantial and permanent in character.

The decision to electrify the road between Harlowton, Montana, and Avery, Idaho, a distance of 438 miles, was announced early in 1913. This section of the line crosses three mountain ranges—the Big Belts, Rockies, and Bitter Roots—and includes many miles of grades, reaching a maximum of two per cent, together with a great amount of curvature, the sharpest curves being ten degrees. There are 36 tunnels on the line, practically all of them in the mountain sections. The longest is the St. Paul Pass tunnel, 8771 feet in length, at the summit of the Bitter Root Mountains.

At the time this electrification program was adopted, the steam locomotive had not been developed to its present capacity and efficiency. The locomotives operating on the extension, however, were of comparatively recent construction, and represented the best practice of that period. The great majority of the locomotives working west of Deer Lodge, Montana, were oil burners; while for the coal burners working east of that point, fuel was obtained from the Company's mines at Roundup, 70 miles east of Harlowton. In view, however, of the difficult operating conditions in the mountain district, it was realized that great benefits would result if the line were electrified. Thus, it was deemed inadvisable to operate steam locomotives over long divisions, and runs averaged only about 113 miles. With electrification, these runs could be considerably extended, while the cost of power would be greatly reduced, as abundant water power was available. Furthermore, by means of regeneration, the mountain grades could be descended without using the brakes, thus increasing the safety and reducing the cost of operation. Also important savings could be effected in the wear and tear of brake shoes and equipment, due not only to the greatly reduced time of air-brake application, but also to the far smoother handling of trains made possible by the use of electric locomotives.

That these advantages were realized, will be more fully pointed out later in this article.

The first train operation using an electric locomotive took place on November 30, 1915, when several business cars were hauled from Three Forks to Deer Lodge, a distance of 112 miles. On December 7, Train No. 16, the eastbound "Olympian," was hauled from Butte to Three Forks, a distance of 70 miles over the Continental Divide, by an electric locomotive. This was the first passenger train on the line to be electrically operated.

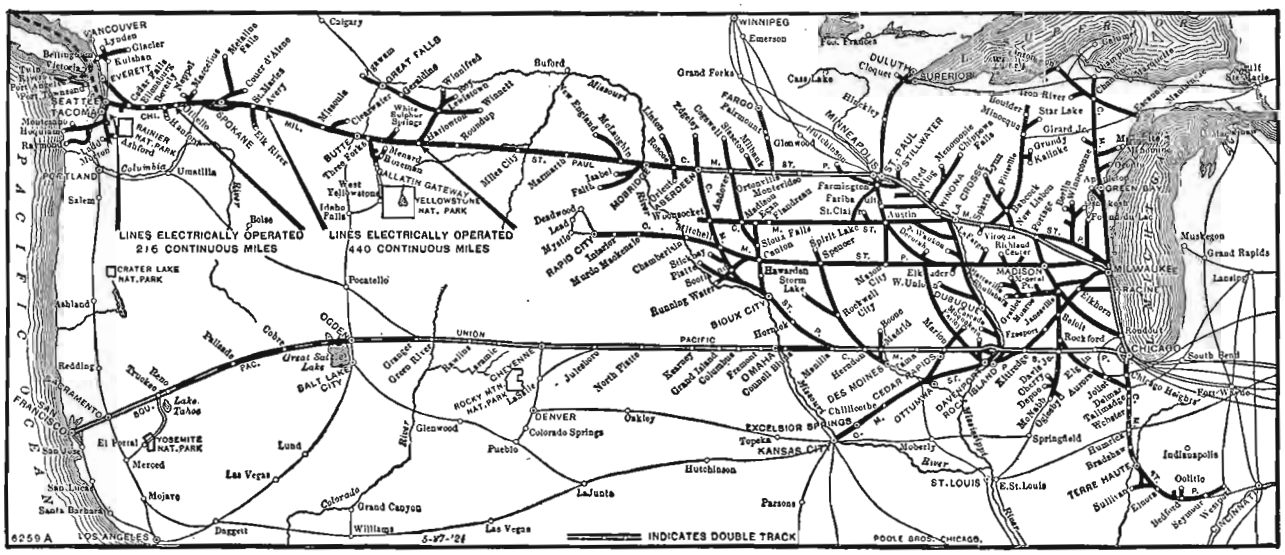
By the end of 1916, the work of electrifying the section between Harlowton and Avery was practically completed; and as the results were fully meeting expectations, the Board of Directors, on January 25, 1917, authorized electrification between Othello and Tacoma, in the State of Washington, a distance of 207 miles. This section crosses the Saddle Mountains at an

elevation of 2455 feet, and the Cascades at an elevation of 2564 feet. The work was completed early in 1920, and the operating results were quite as successful as those on the section between Harlowton and Avery.

Another important step, taken in 1921, was the leasing of the Chicago, Terre Haute & Southeastern Railroad, which furnished the Milwaukee with direct access to the Southern Indiana coal fields, and rendered immediately available an unlimited supply of high-grade locomotive fuel. Indiana coal is now generally used on the lines east of Minneapolis.

The important extensions and developments described above greatly increased the sphere of operations of the Company, but in spite of that fact the management of the Chicago, Milwaukee & St. Paul was, in 1921, facing a trying period. Due largely to the competition of water-borne traffic passing through the Panama Canal, which had been opened in 1914, the operation of the Puget Sound Extension was proving a financial burden. Added to this were adverse economic conditions in the Northwest, resulting in loss of business, and a steady decline in passenger traffic because of automobile competition. These, together with other contributory causes, finally forced the road, on March 18, 1925, into a receivership. This continued until January 13, 1928, when the Chicago, Milwaukee, St. Paul & Pacific Railroad Company assumed control of the property.

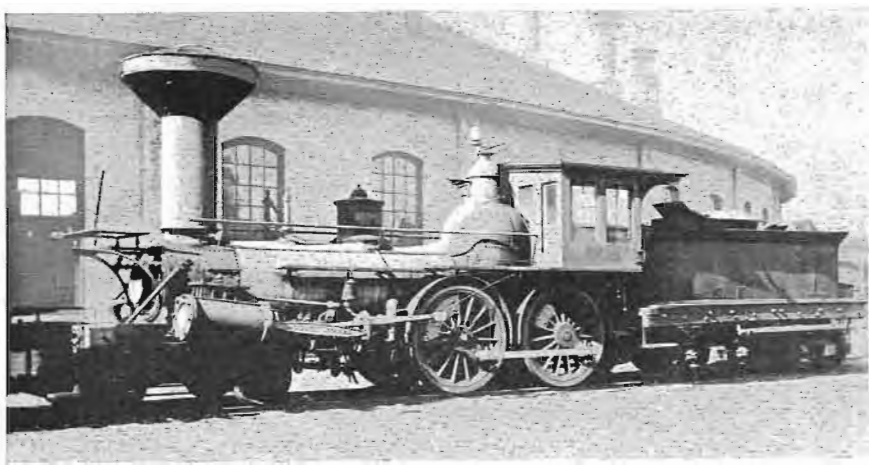
The new management is facing the future cheerfully, and with every confidence in the continued development of the Northwest. It is putting large sums of money into the property, and is steadily raising the standard of service. Heavier rails, creosoted ties, and new ballast are being put into the track, and the older bridges are being strengthened or replaced by strictly modern structures. New equipment has been placed on several important through trains, and the recent acquisition of 15 high-power passenger locomotives of the latest type, marks an important step in the development of the motive power. These various improvements, together with others which are under way or contemplated, will strengthen the prestige of the road and keep it in the front rank among the great railway systems of the country.




Map of the Chicago, Milwaukee, St. Paul & Pacific Railroad

With this brief historical review as a background, the development of the Milwaukee's motive power will now be considered more in detail.

Records indicate that the first locomotive used on the Milwaukee & Waukesha Railroad was built by the Norris Works in Philadelphia in 1848. It was of the 4-4-0 type, with 14 by 26-inch cylinders, and driving wheels approximately 60 inches in diameter over tires; and it weighed 46,000 pounds in working order. The locomotive was outside connected, with inclined cylinders; and the boiler had a firebox of the "hay-stack" or Bury pattern. An



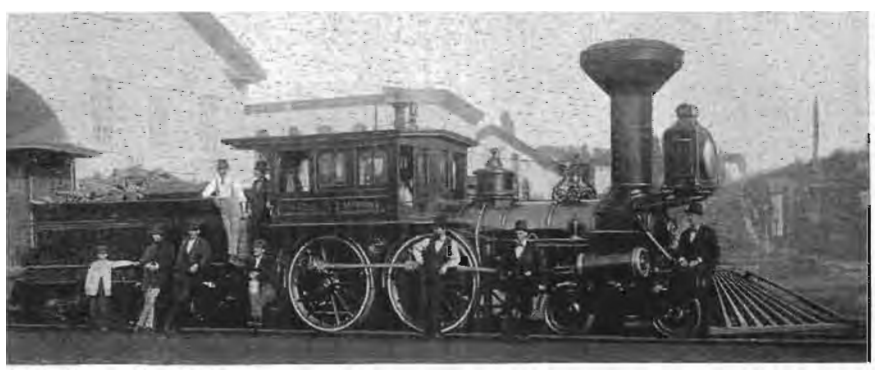
**Left—Engine 71, the *Bob Ellis*, Built by the Norris Works, Philadelphia, in 1848, for the Milwaukee & Waukesha Railroad**

The first locomotive to turn a wheel in Wisconsin.

| | |
|---|---|
| Cylinders | 14" x 26" |
| Drivers, diam. | 60" |
| Fuel | Wood |
| Weight, total engine | 46,000 lb. |

**Below—Another Norris Locomotive, the *Fred Merrill*, No. 37, also Built in 1848**

| | |
|---|---|
| Cylinders | 11" x 24" |
| Drivers, diam. | 61" |
| Fuel | Wood |

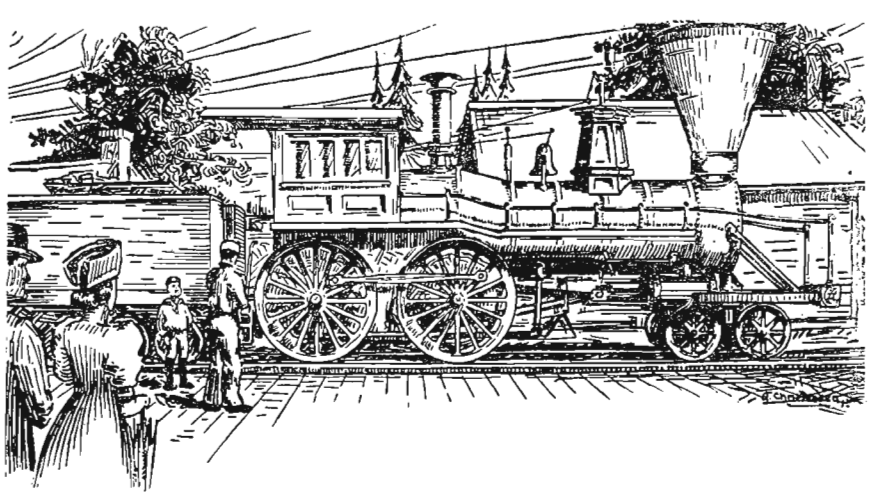


accompanying illustration shows this locomotive as it appeared shortly before being scrapped. Due to partial rebuilding, its appearance had been considerably changed since it was first constructed.

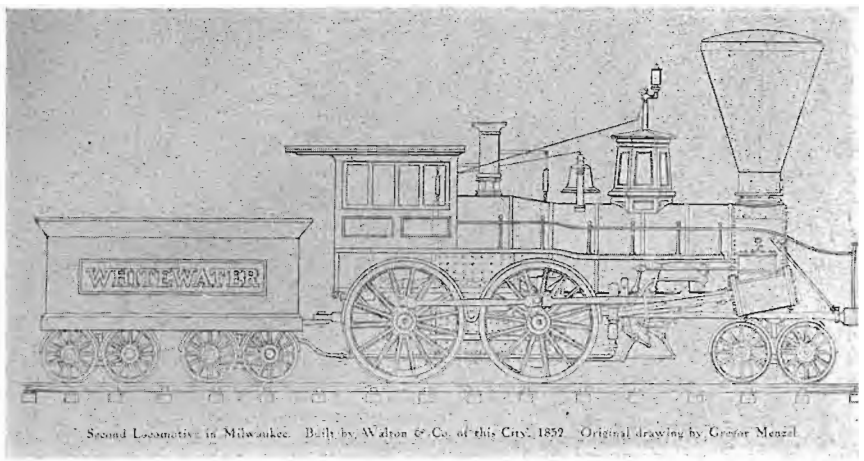
The first locomotive to be built west of Cleveland was undoubtedly the *Menomonee,* constructed in 1852 by Walton & Company at the Menomonee Foundry, Milwaukee, for the Milwaukee & Mississippi Railroad. This was an inside connected locomotive of the 4-4-0 type, and its weight is stated as having been about 26 tons. It was followed, early in 1853, by another locomotive from the same plant, named *Whitewater.* This engine was of the same general dimensions as the *Menomonee,* but was outside connected. These two locomotives are represented in accompanying illustrations.

There has been more or less controversy as to the actual identity of the first locomotive built in Milwaukee, but the facts as given above seem well established in an article entitled "First Locomotive Built in Wisconsin," by George Richardson, which appeared in the *Milwaukee Diamond Jubilee and Homecoming Souvenir,* published in June, 1921. The illustration of the *Menomonee* is taken from an advertisement published by the Second Ward Savings Bank of Milwaukee, in 1924.

A study of the motive power records of the Milwaukee road indicates that, during the first 30 years of its existence, all the locomotives on the line were four-coupled. The great majority were



**The *Menomonee,* Built by Walton & Company, Milwaukee, in 1852, for the Milwaukee & Mississippi Railroad**




The Locomotive *Whitewater*

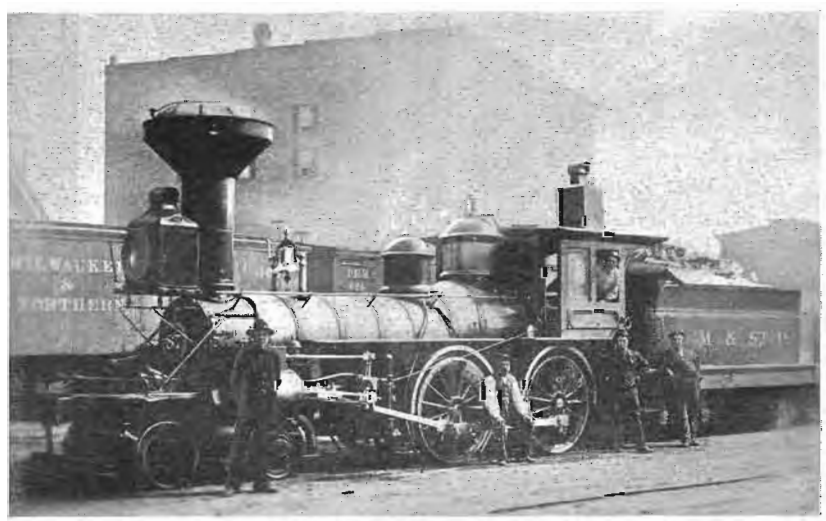
of the 4-4-0 type, which was used for both passenger and freight traffic. This type was flexible and easy on the track, and was comparatively inexpensive to maintain. The various builders had their own ideas as to details of design, but within a comparatively few years after the opening of the road, the basic features of the type became practically standardized. These features included a wide-spread truck, horizontal cylinders, Stephenson link motion, and a deep firebox suitable for burning either bituminous coal or wood, and placed between the frames and driving axles. Opinions varied as to the best boiler design, and both the straight and wagon-top types, with either one or two domes, were used. Steel was being employed, to a limited extent, for boilers and fireboxes, and tubes were of either iron or copper.

The accompanying illustrations show a number of American type locomotives constructed for the Milwaukee road by various builders. One of the most interesting is a locomotive numbered 42, which was originally built in 1854, and evidently rebuilt, with piston valves, by the Railway Company in 1868. A similar locomotive, No. 60, was rebuilt with piston valves in 1869; but the slide valve evidently proved more satisfactory, as the piston valve was not perpetuated.

A statement issued by the Milwaukee & St. Paul Railway Company entitled "Locomotive Exhibit for the Month of December, 1865," gives some interesting data covering the operation of the motive power. Fifty-two locomotives were listed, and the average engine mileage for the month was 1763. The average cost per engine, including wages of engineer and firemen, repairs, oil and waste, foremen, dispatchers and wipers, and wood fuel, was $635.30. The maximum mileage, 3300, was made by engine No. 20, which covered 2310 miles with passenger trains and 990 miles with freight trains. The total operating cost per mile for this locomotive was correspondingly low—22.40 cents.

A similar statement covering the month of October, 1865, contains a foot note which reads in part as follows:

"Passenger and Baggage Cars considered equal to 2 Freight Cars. 3 empty Freight Cars equal to 2 loaded Cars. Wood is charged at $4.50 per cord. Cost of repairs includes superintendence, rebuilding and all other expenditure. 110 ft. of wood, after being sawed twice, is taken as one cord—considered equal to 128 ft. of 4 foot wood. Wiper's labor is charged to Engines at rate of $1.00 to 100 miles run."

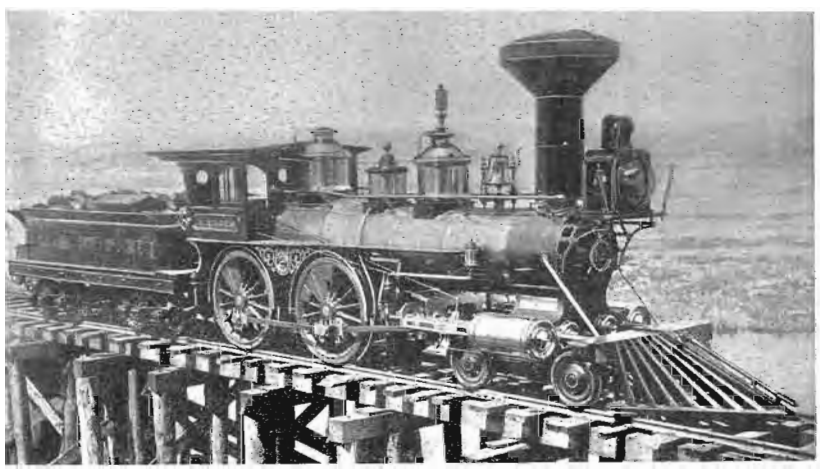


American Type Locomotive, Built by the Schenectady Locomotive Works

| | | | |
|---|---|---|---|
| Cylinders | 15" x 22" | Weight, total engine | 59,000 lb. |
| Drivers, diam. | 63" | Fuel | Wood |

The date of construction is not known.

The records of The Baldwin Locomotive Works fail to disclose any locomotives built for either the Milwaukee & Waukesha or the Milwaukee & Mississippi roads. In 1868, however, three Baldwin locomotives of the American type were built for the Milwaukee & St. Paul Railway. They were wood burners, and had boilers of the straight-top type, with two domes. The boiler shells were of iron, the inside fireboxes of steel, and the tubes of copper. The stack was of the so-called "Yankee" pattern, with a large netting area for catching sparks. Feedwater was supplied by one injector and two crosshead-driven pumps.



**Left—American Type Locomotive, Originally Built in 1854, and Rebuilt by the Railway Company with Piston Valves (as Shown) in 1868**

| | |
|---|---|
| Cylinders | 15" x 24" |
| Drivers, diam. | 62" |
| Grate area | 13 sq. ft. |
| Fuel | Wood |

**Below—American Type Locomotive, Built by William Mason, 1860**

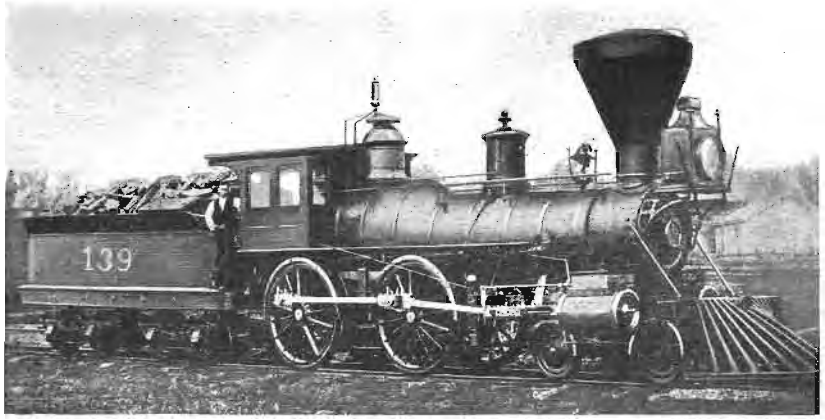
| | |
|---|---|
| Cylinders | 15" x 22" |
| Drivers, diam. | 61" |
| Grate area | 11.6 sq. ft. |
| Weight on drivers | 39,300 lb. |
| " total engine | 62,450 lb. |

These locomotives had 16 x 24-inch cylinders and driving wheels 61¾ inches in diameter. They probably weighed, each, about 63,000 pounds in working order.

A fourth locomotive of generally similar dimensions to those just described, but having a somewhat larger firebox fitted for burning bituminous coal, was built by The Baldwin Locomotive Works for the Milwaukee & St. Paul in May, 1873. It was followed, late in the same year, by two switchers of the 0–4–0 type. These had cylinders measuring 14 x 22 inches, and driving wheels 49 inches in diameter. The weight of each locomotive was about 42,000 pounds, and separate tenders were provided, with tanks of 1600 gallons capacity.

A record of the locomotives in service on the Chicago, Milwaukee & St. Paul Railway in 1874, shows 200 engines on the line, all of them with two pairs of driving wheels, and the great majority evidently of the American (4–4–0) type. The largest of these locomotives had cylinders measuring 16 x 24 inches, and weighed 63,100 pounds each in working order. Many burned wood for fuel, but the use of coal was steadily increasing. Boiler shells were generally of iron, flues of iron or copper, and inside fireboxes of iron or steel, the latter material predominating in the newer locomotives. Steel tires of foreign manufacture, furnished by Krupp, Vickers, and Firth, were conspicuous; while the tires of some locomotives were specified as "Butcher," and were evidently manufactured in the plant near Lewistown, Pennsylvania, which was subsequently acquired by the Standard Steel Works Company.

The 200 locomotives owned by the road in 1874, included the product of almost



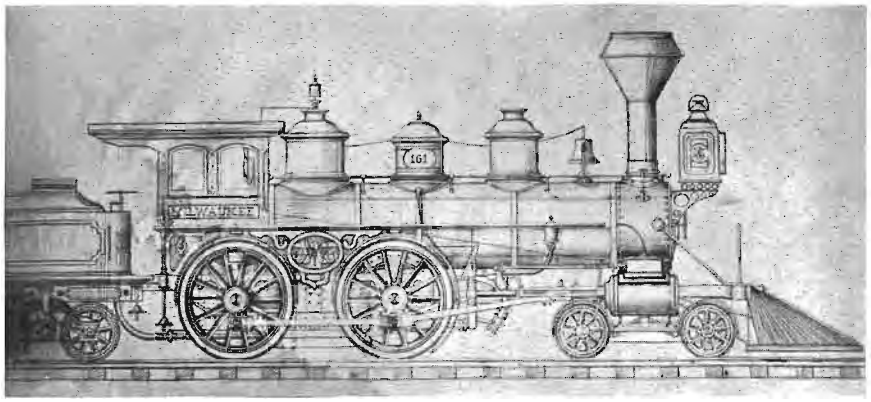

**Left—American Type Locomotive, Built by Danforth, Cooke & Co., 1869**

| | |
|---|---|
| Drivers, diam. | 62″ |
| Grate area | 14.2 sq. ft. |
| Fuel | Wood |
| Weight, total engine | 60,500 lb. |

**Below—American Type Locomotive, Built by William Mason, 1872**

| | |
|---|---|
| Cylinders | 16″ x 24″ |
| Drivers, diam. | 62″ |
| Grate area | 16.6 sq. ft. |

Used in fast passenger service between Chicago and Milwaukee, making the run in three hours.

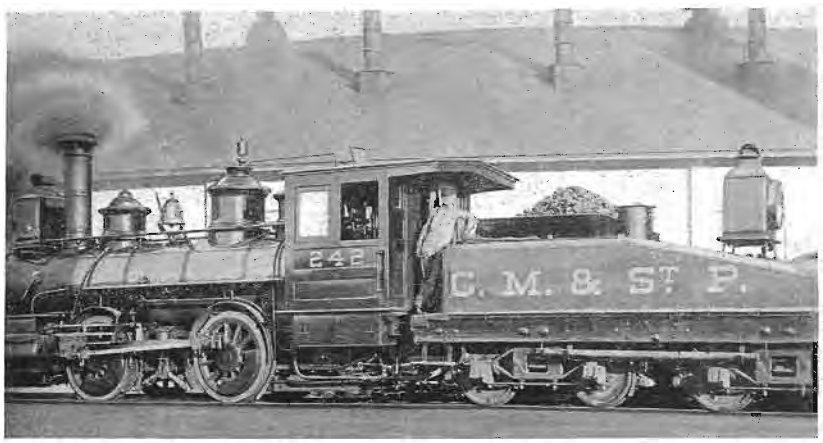



every builder of repute in the country. Comparatively few of these locomotives were constructed in the Middle West, but New England builders were largely represented. The lack of standardization in the details of these locomotives may be imagined.

In May and June, 1880, The Baldwin Locomotive Works completed ten locomotives of the American (4–4–0) type for the Chicago, Milwaukee & St. Paul. They were of conservative dimensions and presented no features of special interest. The illustration of engine 304, on page 12, represents the general design.

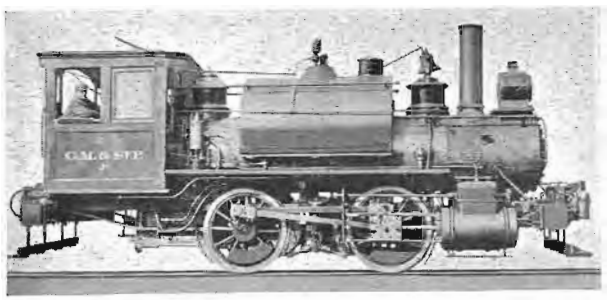
In 1881, the American type was finally abandoned for the heaviest freight service, and 30 locomotives of the ten-wheeled (4–6–0) type, built by the Rhode Island Locomotive Works, were placed in service. These were coal burners, weighing 102,600 pounds, of which 76,700 pounds were carried on the drivers. The cylinder dimensions were 19 x 26 inches, and the drivers were 55 inches in diameter. Contemporary with these locomotives were 30 of the American type, for passenger service, constructed by the same builders. They had 17 x 24-inch cylinders and driving wheels 62 inches in diameter, and weighed 86,150 pounds, with 55,450 pounds on drivers. The acquisition of these two classes marked an interesting step in the motive power development of the road; because, for the first time, the types of power used in passenger and freight service were differentiated.

The locomotive register published on October 1, 1886, showed 705 engines on the road. The largest of these




**Four-coupled Switching Locomotive, Built by the Rogers Locomotive Works, 1879**

| | | | |
|---|---|---|---|
| Cylinders | 16″ x 22″ | Grate area | 12.2 sq. ft. |
| Drivers, diam. | 50″ | Weight, total engine | 63,000 lb. |



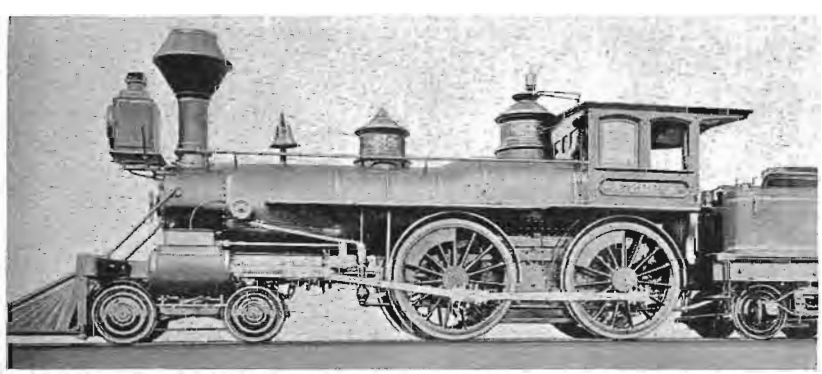
**Four-coupled Switching Locomotive, Originally with Separate Tender, Built by The Baldwin Locomotive Works, 1882**

| | | | |
|---|---|---|---|
| Cylinders | 15" x 24" | Drivers, diam. | 51" |
| | Weight, total | 63,000 lb. | |

were of the ten-wheeled (4–6–0) type, built in that year by the Schenectady Locomotive Works. They had the same size cylinders as the Rhode Island ten-wheelers built in 1881, but the diameter of the driving wheels was increased to 62 inches, and the boiler was larger. These changes increased the total weight to 111,100 pounds, of which the drivers carried 84,500 pounds. Contemporary with these freight locomotives was a group of American (4–4–0) type locomotives for passenger service, built at the Rhode Island Works. They had 18 x 24-inch cylinders and driving wheels 70 inches in diameter. The total weight was 100,200 pounds, with 64,100 pounds on driving wheels. The illustrations of engines 704 and 705, on page 13, represent similar locomotives built by the Brooks Locomotive Works.

With the growth of the System, locomotives were being ordered in fairly large groups, and efforts were being made to standardize the details of the various classes.

In 1889, two heavy passenger locomotives, one built by the Rhode Island Locomotive Works and the other by the Schenectady Locomotive Works, were placed in service on the 85-mile run between Chicago and Milwaukee. They were built under a guarantee to handle 15 cars on a schedule of 2½ hours, including ten stops and slow running through the suburbs of the two cities. The Rhode Island locomotive was of the ten-wheeled (4–6–0) type, with a deep firebox placed between the frames and having a grate area of 18.4 square feet. The cylinders were 19 inches in diameter by 24 inches stroke, and the driving wheels were 64 inches in diameter. The Schenectady locomotive had the same size cylinders, but the driving wheels were 69 inches in diameter, and the boiler had a long firebox placed above the engine frames and providing a grate area



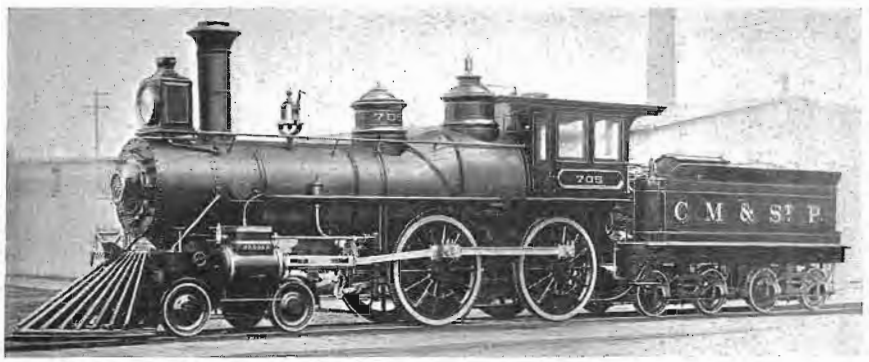
**American Type Locomotive, Built by the Schenectady Locomotive Works, 1877**

| | |
|---|---|
| Cylinders | 17" x 24" |
| Drivers, diam. | 68" |
| Grate area | 15.8 sq. ft. |
| Weight on drivers | 48,000 lb. |
| " total engine | 76,000 lb. |

On June 9, 1880, this locomotive hauled General Grant from Chicago to Milwaukee in 2 hours 10 minutes. The engineer was C. McCollum, and the conductor of the train was F. D. Underwood, who subsequently became one of the most prominent and successful railroad officials in the United States.

**American Type Locomotive, Built by The Baldwin Locomotive Works, 1880**

| | |
|---|---|
| Cylinders | 16" x 24" |
| Drivers, diam. | 63" |
| Steam pressure | 130 lb. |
| Grate area | 15.5 sq. ft. |
| Heating surface | 935 sq. ft. |
| Weight on drivers | 42,750 lb. |
| " total engine | 68,550 lb. |
| Tractive force | 10,800 lb. |




**Left — American Type Locomotive, Built 1886**

| | |
|---|---|
| Cylinders | 18" x 24" |
| Drivers, diam. | 69" |
| Grate area | 17.3 sq. ft. |
| Weight on drivers | 64,100 lb. |
| " total engine | 100,200 lb. |

**Below—Ten-wheeled Locomotive, Built 1887**

| | |
|---|---|
| Cylinders | 19" x 26" |
| Drivers, diam. | 63" |
| Grate area | 18.7 sq. ft. |
| Weight on drivers | 84,500 lb. |
| " total engine | 111,100 lb. |

of 30.4 square feet. The design was similar to that of a ten-wheeler, but as it was found impossible to keep the weight on the driving wheels within the specified limits, a two-wheeled radial truck, equalized with the drivers, was placed under the extreme rear end of the frames. The general features of the design are shown in the accompanying illustration of engine 796.


*Photos furnished by American Locomotive Company*

**Passenger and Freight Locomotives Built by the Brooks Locomotive Works**

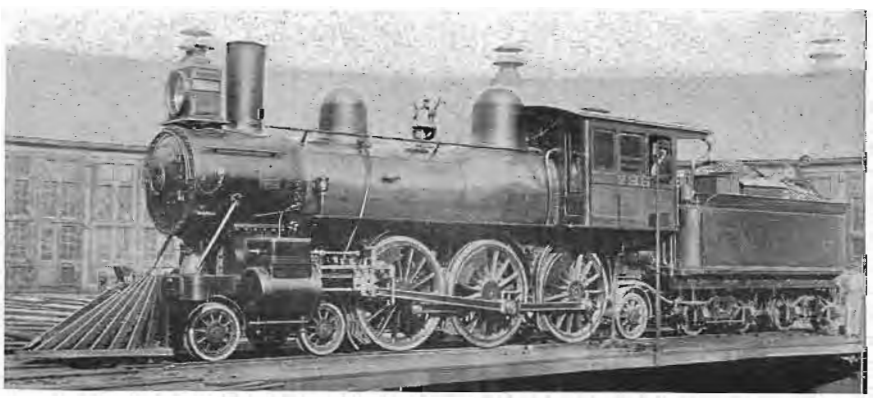
While this locomotive had the same wheel arrangement as the subsequently developed Pacific type, it can hardly be considered the first of that type, as the arrangement of the firebox, with reference to the frames and wheels, was the same as in the ten-wheeled type. The locomotive rendered good service, and later, when increased wheel loads became permissible due to heavier track construction, the rear truck was removed.

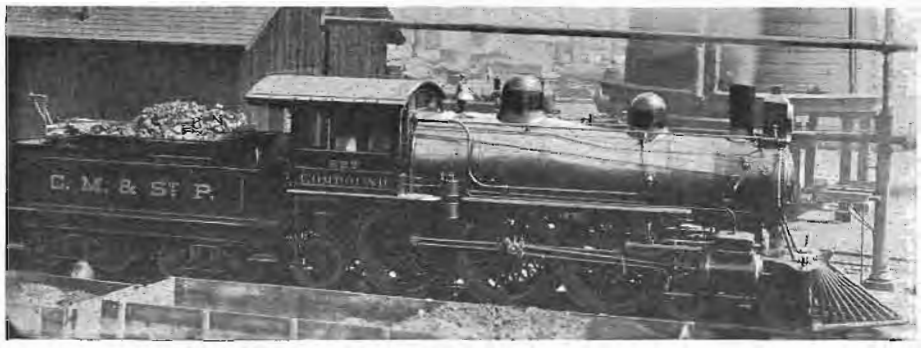
A second locomotive with the 4-6-2 wheel arrangement, designed for heavy passenger service, was built for the Milwaukee by the Rhode Island Locomotive Works, and exhibited by the builders at the World's Columbian Exposition, held in Chicago in 1893. This locomotive, illustrated on page 14, attracted much attention, as it was a two-cylinder compound, with driving wheels 78 inches in diameter. The rear truck carried a load of 19,000 pounds. The locomotive was placed in operation between Chicago and Milwaukee, but it was comparatively short-lived, as it failed to measure up to the service requirements.

Another locomotive of unusual design which should be mentioned in this connection, was the *James Toleman*, which was built by R. & W. Hawthorn, Leslie & Co., Ltd., of England, in accordance with the patents of F. C. Winby, and exhibited at the Columbian Exposition. This locomotive

**Six-coupled Passenger Locomotive, 4-6-2 Type, Built by the Schenectady Locomotive Works, 1889**

| | |
|---|---|
| Cylinders | 19" x 24" |
| Drivers, diam. | 69" |
| Steam pressure | 165 lb. |
| Grate area | 30.4 sq. ft. |
| Heating surface | 1745 sq. ft. |
| Weight on drivers | 88,000 lb. |
| " total engine | 131,000 lb. |
| Tractive force | 17,600 lb. |

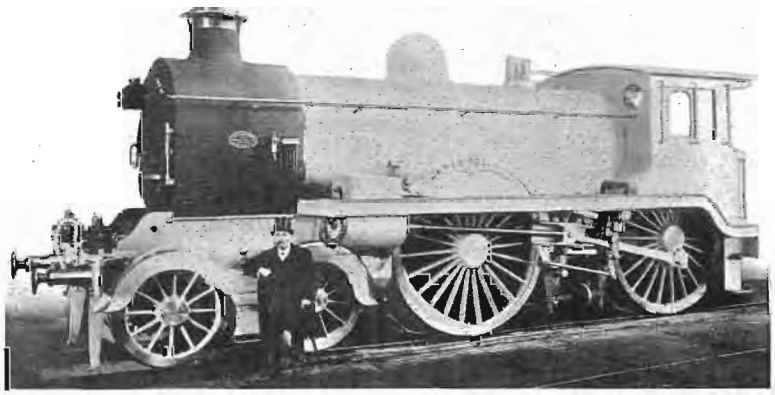





| | |
|---|---|
| Cylinders | 21" & 31" x 26" |
| Drivers, diam. | 78" |
| Steam pressure | 200 lb. |
| Grate area | 27 sq. ft. |
| Heating surface | 1788 sq. ft. |
| Weight on drivers | 90,000 lb. |
| " total engine | 150,000 lb. |
| Tractive force (compound) | 17,700 lb. |

**Six-coupled, 4-6-2 Type, Compound Passenger Locomotive, Built by the Rhode Island Locomotive Works, 1893**

had two pairs of driving wheels and a four-wheeled leading truck or bogie. There were four cylinders, two placed outside the frames, with their pistons connected to the rear drivers, and the other two placed between the frames, their pistons being connected to the forward pair of drivers, which had a cranked axle. The boiler was of most peculiar construction, the sides of the barrel being flattened so that it could be placed between the large drivers without raising the center line to an excessive height. The general design included many other novel features.



**The British-built Locomotive *James Toleman***

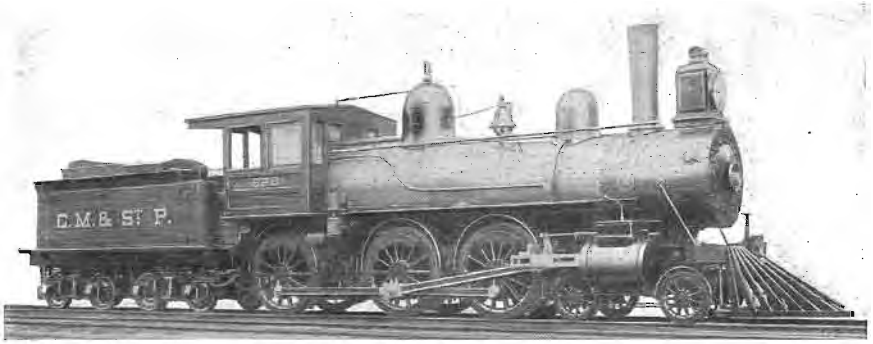
| | | | |
|---|---|---|---|
| Cylinders (inside) | 17" x 22" | Drivers, diam. | 90" |
| " (outside) | 16½" x 24" | Weight, total engine | 134,400 lb. |

After the close of the Exposition, this locomotive was sent to the Milwaukee road for trial, and was fitted with the Railway Company's standard pilot, sandbox, bell, headlight, grates, ashpan, and smokebox arrangement. It proved a failure, however, as it could not be made to steam. This, the inventor claimed, was due to the quality of coal used. The locomotive was then sent to Purdue University for exhibition, and was subsequently scrapped.

At the Columbian Exposition, the locomotives exhibited included a large number of compounds of various types. Reference has been made to one of these locomotives, which was built by the Rhode Island Locomotive Works for the Milwaukee road. The compound, when suitably designed for the service and intelligently operated, was proving its ability to save fuel and water and to develop increased capacity per ton of locomotive weight,

**American Type Locomotive, Built at Milwaukee Shops, 1893**

| | | | |
|---|---|---|---|
| Cylinders | 16" x 24" | Grate area | 17.5 sq. ft. |
| Drivers, diam. | 62" | Weight on drivers | 54,000 lb. |
| Steam pressure | 160 lb. | " total engine | 86,000 lb. |
| | Tractive force | 13,500 lb. | |




Ten-wheeled Locomotive, Built by The Baldwin Locomotive Works, 1892

| | |
|---|---|
| Cylinders | 18" x 26" |
| Drivers, diam. | 62" |
| Steam pressure | 180 lb. |
| Grate area | 18.4 sq. ft. |
| Heating surface | 1679 sq. ft. |
| Weight on drivers | 84,800 lb. |
| " total engine | 117,000 lb. |
| Tractive force | 20,800 lb. |

Compound locomotive No. 827, illustrated below, had cylinders 12" and 20" in diameter, and carried a steam pressure of 190 pounds. Otherwise it was similar to engine 820.

as compared with the single expansion engine.

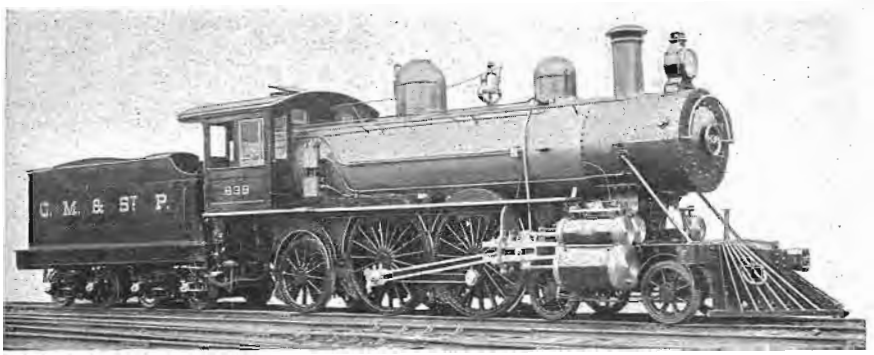
In 1889, the first compound locomotive of the Vauclain four-cylinder type was built by The Baldwin Locomotive Works. The characteristic features of this type are so well known that they need be mentioned only briefly in this connection. A high-pressure and a low-pressure cylinder were placed, one above the other, on each side of the locomotive, with the two pistons connected to a common crosshead of suitable design. A single piston valve on each side controlled the steam distribution. There were therefore four exhausts to each revolution of the drivers, and the two sides of the locomotive were symmetrical as far as cylinders and machinery were concerned.

The promising results shown by this first engine, which was built for the Baltimore & Ohio Railroad, aroused much interest on the part of railroad officials. A large number of roads purchased compound locomotives for experimental purposes, and subsequently ordered them in considerable numbers where they proved suitable for the service requirements. Among these roads was the Chicago, Milwaukee & St. Paul, on which operating conditions proved most favorable to the compound.

The first Vauclain compound locomotive built for the Milwaukee was completed in January, 1892. It was one of a group of ten locomotives of the ten-wheeled (4–6–0) type, the remaining nine being in all respects similar to it, except that they had single expansion cylinders. These locomotives were intended for freight service, and had driving wheels 62 inches in diameter. The boiler was of the extended wagon-top type, with a deep firebox placed between the second and third driving axles. The firebox was radially stayed, and it contained a brick arch supported on water tubes, and also had combustion tubes in the water legs, for the purpose of admitting air above the fire. This arrangement of brick arch and combustion tubes was applied to a large number of locomotives subsequently built for the road.

The cylinders of the compound locomotive were proportioned with the intention of providing approximately the same hauling capacity as the single expansion, the compound carrying a pressure of 190 pounds, while the others carried 180 pounds. Tests, however, indicated the desirability of increasing the cylinder dimensions of the compound, and this was done in a group of ten locomotives built in December, 1895. With the exception of a slight reduction in the number of tubes, the boilers of these

The First Vauclain Compound Locomotive Built for the Milwaukee Road, under Test with the Dynamometer Car




| | |
|---|---|
| Cylinders | 13" & 22" x 26" |
| Drivers, diam. | 78" |
| Steam pressure | 200 lb. |
| Grate area | 30.1 sq. ft. |
| Heating surface | 2233 sq. ft. |
| Weight on drivers | 71,600 lb. |
| " total engine | 140,700 lb. |
| Tractive force (compound) | 15,600 lb. |

**Compound Atlantic Type Locomotive, Built by The Baldwin Locomotive Works, 1896**

locomotives were of the same dimensions as the boiler of the experimental compound. The steam pressure was raised to 200 pounds, and this, in conjunction with larger cylinders and piston valves, materially increased the hauling capacity of the new engines.

Late in 1892, the Milwaukee received, from The Baldwin Locomotive Works, a group of eight locomotives of the American (4-4-0) type. These were comparatively light locomotives, with 16 x 24-inch cylinders, and as they exerted practically no influence on the subsequent development of the road's motive power, they are of little interest in this connection.

The Milwaukee was now confronted with the necessity of providing power of greater capacity for its fast passenger service. It was desired to run between Chicago and Milwaukee, 85 miles, in one hour 45 minutes, with a train of nine cars averaging not more than 70,000 pounds weight per car. Allowing for slow speed within city limits, this meant that 74 miles would have to be run in 77 minutes, including one station stop and four slowdowns. These were difficult requirements to meet, especially in view of the fact that the locomotives operating on this division were limited in weight to 36,000 pounds per pair of drivers.

The Baldwin Locomotive Works met this requirement with two locomotives of the Atlantic (4-4-2) type, which were completed in May, 1896. The Atlantic was a comparatively new type at that time, but a number were in operation and were demonstrating the suitability of the type for fast passenger service in which high steaming capacity in proportion to adhesion was essential.

The accompanying illustration of engine 838 shows the principal features of the design built for the Milwaukee road. The boiler had a straight top, with a deep firebox placed above the frames and back of the rear driving axle. A pair of trailing wheels, held in rigid pedestals, was placed under the firebox. The cylinders were of the Vauclain compound type, cast from a pattern a size larger than that to which they were actually bored, and fitted with the larger size of cylinder heads. Piston valves 11½ inches in diameter controlled the steam distribution. The front truck had a swing bolster, and the tires on all the wheels under the locomotive were flanged. The tender had a frame of yellow pine, with oak bumpers; and the tank, which was of 4500 gallons capacity, was fitted with a water scoop.

These locomotives were a remarkable success from the start. On July 3, 1896, engine 839, which had been in service but a short time, hauled a train of 13 cars from Forest Glen, near Chicago, to National Avenue, Milwaukee, in 82 minutes, including one stop of five minutes and several slowdowns. The distance run was 74 miles, and the total weight of the train, including the locomotive and tender, was 1,200,000 pounds. When the results of this run were published, *The Engineer* (London) questioned them, and the editor undertook to demonstrate that the locomotive was practically incapable of such a performance. He also offered a severe criticism on the design of the locomotive. Mr. S. M. Vauclain, who was then General Manager of The Baldwin Locomotive Works, responded with an interesting statement which was published in the *Railroad Gazette* of March 19, 1897. This statement demonstrated

the fact that the locomotive was capable of making the run in question, and also defended the design as being entirely suitable to meet the service requirements on the Milwaukee road. It is interesting to note that not many years later the Atlantic type was introduced in Great Britain, and was subsequently extensively adopted in that country for fast passenger service.

Two additional Atlantic type locomotives, which were duplicates of engines 838 and 839, and bore the road numbers 840 and 841, were ordered in 1897 and completed in August of that year. Five more followed in November, 1898, and an additional four in November, 1899. These locomotives were all built to the same general design and dimensions, and the successive orders showed differences in minor details only.

Contemporary with these Atlantic type locomotives, were several groups of ten-wheeled (4–6–0) type locomotives designed for fast freight service. Conditions on the Milwaukee road were particularly favorable to the use of this type of power. With moderate grades on the main lines, and a large volume of preference freight such as live stock and agricultural products, it was essential that the traffic be moved at comparatively high speeds. Ten-wheeled locomotives met the conditions admirably. They could also be used on passenger trains if necessary, and thus constituted a very useful type of power for general road service.

The first compound ten-wheelers, built in 1892 and 1895, have already been briefly described. Four additional locomotives, similar to those built in 1895, were completed in August, 1897. These were followed, in September of the same year, by a new class having larger cylinders and greater steaming capacity. The boiler had a long firebox placed above the frames, and was practically a duplicate of that used on the Atlantic type passenger locomotives. The driving wheel diameter, 62 inches, was the same as that of the previous ten-wheelers. The class is illustrated below.

In May, 1899, two new ten-wheelers for fast freight service, numbered 252 and 253, were built by The Baldwin Locomotive Works. They were similar in general design, but the 252 had a larger boiler, and cylinders of greater diameter, than the 253. In both classes the piston stroke was 30 inches, and the driving wheel diameter 68 inches. This was considered, at that time, a rather unusual combination in a six-coupled freight locomotive. The boiler, in each case, was of the extended wagon-top type, with a firebox nine feet long, placed above the frames and providing a grate area of 31.5 square feet. The company's standard arrangement of brick arch supported on water tubes, and of combustion tubes in the water legs, was applied. The tender tanks were each of 3800 gallons capacity, and were mounted on wood frames.

A study of the various designs of ten-wheeled locomotives built for the road during the years 1892 to 1903, clearly shows the tendency to increase the steaming capacity in proportion to the tractive force developed. The table on page 19, which gives the principal dimensions of these locomotives, shows this plainly. In two classes built in 1900, designated by the road numbers 301 and 351 respectively, the firebox length was increased to ten feet, giving a grate area of 35.1 square feet. Any further increase in length was practically prohibitive in a hand-fired locomotive, and therefore in the group of locomotives numbered 367-400, built in 1901, the wide firebox was adopted. The box had straight side sheets and the width of the grate was 65⅞ inches. The grate sloped toward the

| | |
|---|---|
| Cylinders | 13½" & 23" x 26" |
| Drivers, diam. | 62" |
| Steam pressure | 200 lb. |
| Grate area | 30.1 sq. ft. |
| Heating surface | 2209 sq. ft. |
| Weight on drivers | 106,200 lb. |
| " total engine | 149,600 lb. |
| Tractive force (compound) | 21,300 lb. |


**Compound Ten-wheeled Locomotive, Built by The Baldwin Locomotive Works, 1897**

front, giving a depth of 22 inches from the under side of the mud-ring to the bottom of the arch at the tube sheet. As compared with the previous heavy ten-wheelers, the drivers were reduced in diameter and the piston stroke was shortened. The tank capacity was increased to 7000 gallons.

It is interesting to note that in a group of lighter ten-wheelers, built in August, 1900, and bearing the road numbers 252 to 258, cast steel frames were used. Apparently they did not prove as satisfactory as forged iron frames, since a return to the latter material was made in several groups of locomotives subsequently built.

These large Atlantics were followed, in 1902, by fifteen of similar design, and by four more in 1903. Contemporary with this latter group were five lighter Atlantics, which were similar in general dimensions and design to those built during the years 1896 to 1899. The tenders of all these locomotives had oak frames and tanks of 7000 gallons capacity.

Reverting now to power for freight service, it is interesting to note that the first eight-coupled locomotives built for the Milwaukee, were completed by The Baldwin Locomotive Works in August, 1901. They were four in number, of the Consolidation (2-8-0) type, with 22 x 28-inch cylinders and driving wheels 56 inches in diameter. In order to determine the relative efficiencies of narrow and wide fireboxes on heavy power of this type, two of the locomotives had grates measuring 120⅛ x 42⅛ inches, with 35.1 square feet of area, while the other two had grates measuring 101⅞ x 65⅞ inches, the area in this case being 46.5 square feet. The engine frames were of forged iron, and the running gear and machinery were alike in the four locomotives. The locomotives with wide fireboxes proved the more efficient. Additional engines of similar design were subsequently built in the shops of the Railway


| | |
|---|---|
| Cylinders | 15" & 25" x 30" |
| Drivers, diam. | 68" |
| Steam pressure | 200 lb. |
| Grate area | 35.1 sq. ft. |
| Heating surface | 2952 sq. ft. |
| Weight on drivers | 135,600 lb. |
| " total engine | 178,900 lb. |
| Tractive force (compound) | 27,000 lb. |

**Compound Ten-wheeled Locomotive, Built by The Baldwin Locomotive Works, 1900**

| | |
|---|---|
| Cylinders | 15" & 25" x 28" |
| Drivers, diam. | 62" |
| Steam pressure | 200 lb. |
| Grate area | 46.5 sq. ft. |
| Heating surface | 2903 sq. ft. |
| Weight on drivers | 126,500 lb. |
| " total engine | 176,200 lb. |
| Tractive force (compound) | 27,700 lb. |


**Compound Ten-wheeled Locomotive with Wide Firebox, Built by The Baldwin Locomotive Works, 1901**

Contemporary with the first wide firebox ten-wheelers were nine locomotives of the Atlantic type that had wide fireboxes, and were of greatly enlarged dimensions as compared with the earlier Atlantics. The driving wheel centers of these locomotives were of cast steel, 78 inches in diameter, which with tires three inches thick, gave an overall diameter of 84 inches. Plain tires were used on the forward drivers, and the leading truck had a rigid center. This was a rather unusual arrangement, as on all the other Atlantic type locomotives built for the Milwaukee, the truck had a swing bolster and all the tires were flanged. The main frames were of forged iron.

## Compound Ten-Wheeled Locomotives—Chicago, Milwaukee & St. Paul Railway

| Road Number | Date | Cylinders | Drivers Diameter | Steam Pressure Pounds | Grate Area Square Feet | Heating Surface Square Feet | Weight on Drivers Pounds | Weight Total Engine Pounds | Tractive Force (Compound) Pounds |
|---|---|---|---|---|---|---|---|---|---|
| 827 | 1892 | 12″ / 20″ x 26″ | 62″ | 190 | 18.4 | 1679 | 88,650 | 119,800 | 15,600 |
| 828 | 1895 | 12½″ / 21″ x 26″ | 62″ | 200 | 18.4 | 1645 | 91,300 | 125,500 | 18,000 |
| 846 | 1897 | 13½″ / 23″ x 26″ | 62″ | 200 | 30.1 | 2209 | 106,200 | 149,600 | 21,300 |
| 252 | 1899 | 15″ / 25″ x 30″ | 68″ | 200 | 31.5 | 2745 | 133,320 | 172,370 | 27,000 |
| 253 | 1899 | 14″ / 24″ x 30″ | 68″ | 200 | 31.5 | 2447 | 120,000 | 164,000 | 24,200 |
| 301 | 1900 | 15″ / 25″ x 26″ | 68″ | 200 | 35.1 | 2715 | 123,300 | 166,800 | 23,500 |
| 351 | 1900 | 15″ / 25″ x 30″ | 68″ | 200 | 35.1 | 2952 | 135,600 | 178,900 | 27,000 |
| 252 | 1900 | 13½″ / 23″ x 26″ | 62″ | 200 | 30.1 | 2510 | 112,100 | 152,300 | 21,300 |
| 367 | 1901 | 15″ / 25″ x 28″ | 62″ | 200 | 46.5 | 2903 | 126,500 | 176,200 | 27,700 |

| | |
|---|---|
| Cylinders | 15″ & 25″ x 28″ |
| Drivers, diam. | 84″ |
| Steam pressure | 200 lb. |
| Grate area | 46.7 sq. ft. |
| Heating surface | 3192 sq. ft. |
| Weight on drivers | 100,330 lb. |
| " total engine | 181,530 lb. |
| Tractive force (compound) | 20,500 lb. |


**Compound Atlantic Type Locomotive with Wide Firebox, Built by The Baldwin Locomotive Works, 1901**

Company. They are included in the group now designated as Class C1.

The success of the Class C1 locomotives in heavy freight service, resulted in the subsequent use of larger engines of the Consolidation type. In 1910, The Baldwin Locomotive Works built 50 locomotives of Class C2, in which the cylinder dimensions were increased to 23 x 30 inches, and the tractive force to 42,820 pounds. Twenty-five locomotives of the same class were built at the Milwaukee shops.

In 1912, Class C5 appeared, and 50 locomotives were built by the American Locomotive Company and the Milwaukee Shops. The design was based directly on that of Class C2, but the cylinder diameter was increased to 24 inches and a superheater was applied.

The Class C5 locomotives are the largest of the Consolidation type in service on the Milwaukee road, with the exception of a group of engines designated as Class C7, which were acquired with the lease of the Chicago, Terre Haute & South-eastern Railroad in 1921. Class C7 has 25 x 32-inch cylinders, weighs 240,000 pounds in working order, and develops a tractive force of 50,160 pounds.

The use of cast steel frames, first applied to a group of ten-wheelers built in 1900, was resumed in 17 heavy ten-wheelers of Class B4 built in 1903, and thereafter frames of this material were regularly applied to the locomotives built for the Milwaukee by The Baldwin Locomotive Works.

During the early years of the present


| | |
|---|---|
| Cylinders | 22" x 28" |
| Drivers, diam. | 56" |
| Steam pressure | 200 lb. |
| Grate area | 46.6 sq. ft. |
| Heating surface | 2608 sq. ft. |
| Weight on drivers | 156,400 lb. |
| " total engine | 177,000 lb. |
| Tractive force | 41,140 lb |

**Consolidation Type, Class C1-c, Built at the Milwaukee Shops, 1904**

| | |
|---|---|
| Cylinders | 23" x 30" |
| Drivers, diam. | 63" |
| Steam pressure | 200 lb. |
| Grate area | 48.8 sq. ft. |
| Heating surface | 3370 sq. ft. |
| Weight on drivers | 189,200 lb. |
| " total engine | 215,700 lb. |
| Tractive force | 42,820 lb. |


**Consolidation Type Locomotive, Class C2, Built at the Milwaukee Shops, 1910**


*Photo furnished by American Locomotive Co.*

| | |
|---|---|
| Cylinders | 24" x 30" |
| Drivers, diam. | 63" |
| Steam pressure | 185 lb. |
| Grate area | 48.8 sq. ft. |
| Water heating surface | 2660 sq. ft. |
| Superheating surface | 652 sq. ft. |
| Weight on drivers | 197,500 lb. |
| " total engine | 224,000 lb. |
| Tractive force | 43,130 lb. |

**Consolidation Type Locomotive, Class C5-a, Built by the American Locomotive Company, 1912**

century, the balanced compound type of locomotive was attracting much attention in the United States. This was chiefly due to the success of the so-called de Glehn type, which was extensively used in France. The Baldwin Locomotive Works introduced a design of balanced compound which was specially suited to the conditions prevailing on American roads; and two such locomotives, having the Atlantic type wheel arrangement, were built for the Milwaukee in 1907. In these locomotives, the high-pressure cylinders were placed between the frames and the low-pressure outside, and all four pistons were connected to the leading pair of drivers, which had a cranked axle. The driving wheels were 85 inches in diameter.

These locomotives were designed to traverse curves of 20 degrees. The leading truck had a swing bolster, while the two-wheeled trailing truck was of the De Voy type, with lateral motion, as designed by the Railway Company. With a total wheel base of 32 feet two inches, the rigid wheel base was only seven feet six inches. The general design is shown in the accompanying illustration of engine 952.

Experience with the balanced compound locomotives was not as satisfactory as with the original Vauclain type; and accordingly, in the next group of Atlantics, the Vauclain design of compound cylinders was again used. This group consisted of 12 locomotives, which were completed in December, 1908, and January, 1909. The De Voy trailing truck was employed in this design; and these were the first Baldwin engines built for the Milwaukee

road to be fitted with Walschaerts valve gear. The wood tender frame was finally abandoned, steel channels being substituted for the timbers formerly used.

These were the last non-articulated compound locomotives built for the Milwaukee. At the time of their construction, the subject of superheating was receiving much attention, and the economies resulting from its use were being fully demonstrated. With the general introduction of superheating, the building of compound locomotives was practically abandoned in the United States, with the exception of articulated compound locomotives of the Mallet type.

The Vauclain compounds on the Milwaukee did fine work. The organization on the line was trained to handle them well and to maintain them in good condition, and while many of them were subsequently changed to single expansion, the results obtained with this class of power were regarded as satisfactory.

Several years previous to the completion of the last Atlantic type locomotives, there was built, at the Milwaukee Shops of the Railway Company, an experimental locomotive of the Pacific (4–6–2) type. This engine, designed for the heaviest class of passenger service, was completed early in 1905, and was given the road number 851. It had single expansion cylinders, and the steam distribution was controlled by 12-inch piston valves operated by Stephenson link motion. As some trouble had been experienced with the wide fireboxes used on the heavy ten-wheeled and Atlantic type locomotives previously built, the new Pacific type was fitted with a narrow firebox placed above the frames and back of the rear driving axle. The grate area was consequently restricted, the ratio of grate area to total heating surface being as 1 to 94.5. The general features of the design are shown in an illustration on page 22.

This locomotive is of interest, as the Pacific type was used to only a limited extent at the time of its construction, and it represented, for that period, a design of considerable power. It was several years, however, before any additional locomotives of the Pacific type were placed in service on the Milwaukee road.

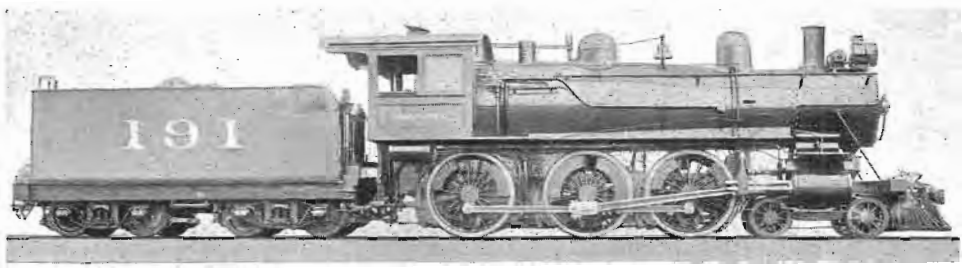
With the approaching completion, in 1907, of the Puget Sound Extension, the Chicago, Milwaukee & St. Paul required a


| | |
|---|---|
| Cylinders | 15″ & 25″ x 28″ |
| Drivers, diam. | 85″ |
| Steam pressure | 220 lb. |
| Grate area | 45.8 sq. ft. |
| Heating surface | 3198 sq. ft. |
| Weight on drivers | 107,550 lb. |
| " total engine | 205,350 lb. |
| Tractive force (compound) | 22,200 lb. |

**Balanced Compound Atlantic Type Locomotive, Built by The Baldwin Locomotive Works, 1907**

| | |
|---|---|
| Cylinders | 15″ & 25″ x 28″ |
| Drivers, diam. | 85″ |
| Steam pressure | 220 lb. |
| Grate area | 44 sq. ft. |
| Heating surface | 3188 sq. ft. |
| Weight on drivers | 108,750 lb. |
| " total engine | 210,400 lb. |
| Tractive force (compound) | 22,200 lb. |


**Vauclain Compound Atlantic Type Locomotive, Class A2-c, Built by The Baldwin Locomotive Works, 1908**




| | |
|---|---|
| Cylinders | 20½" x 26" |
| Drivers, diam. | 73" |
| Steam pressure | 200 lb. |
| Grate area | 30.6 sq. ft. |
| Water heating surface | 1786 sq. ft. |
| Superheating surface | 565 sq. ft. |
| Weight on drivers | 135,700 lb. |
| " total engine | 182,100 lb. |
| Tractive force | 25,450 lb. |

Originally built to use saturated steam.

**Ten-wheeled Locomotive, Class G6-as, Built at the Milwaukee Shops, 1905**

| | |
|---|---|
| Cylinders | 23" x 26" |
| Drivers, diam. | 72" |
| Steam pressure | 200 lb. |
| Grate area | 35.8 sq. ft. |
| Heating surface | 3382 sq. ft. |
| Weight on drivers | 130,500 lb. |
| " total engine | 208,750 lb. |
| Tractive force | 32,600 lb. |


**Pacific Type Locomotive, Class F2, Built at the Milwaukee Shops, 1905**

large number of new locomotives. There was here afforded an excellent opportunity to design classes of power best fitted for the particular work to be done, and having as many interchangeable details as practicable.

It was desired to haul unbroken trains through from the West Coast to Chicago, and the new locomotives were designed with that end in view, bearing in mind the fact that existing locomotives of the ten-wheeled (4–6–0) type would be used east of Minneapolis. The Prairie (2–6–2) type was at that time being adopted for fast freight service by many roads in the Middle West, and the Milwaukee selected the type for work between Minneapolis and the Rocky Mountain region. The 2–6–2 type provided not only a flexible wheel base, with the weight well distributed, but also permitted the application of a boiler with a firebox suitable for burning Round-up coal—a species of lignite mined in Montana, and easily available. The boiler had a conical connection in the middle of the barrel, and the center line was placed nine feet eight inches above the rail. The firebox had a deep throat, placed back of the rear drivers, with a combustion chamber extending forward into the barrel. It contained an arch supported on water tubes. The boiler tubes had the moderate length of 13 feet 3 inches. The three pairs of drivers, 63 inches in diameter, were compactly grouped on a wheel base of eleven feet; and the main rods were connected to the rear pair. The rear truck was of the De Voy lateral motion type. Piston valves were applied, and were operated by Walschaerts gear.

With a boiler pressure of 200 pounds, these locomotives exerted a tractive force of 33,320 pounds; the ratio of adhesion being 4.57.

Fifty of these locomotives, designated as Class K1, were built by the American Locomotive Company at the Brooks Works


*Photo furnished by American Locomotive Co.*

**Prairie Type Locomotive, Class K1, Built by the American Locomotive Company, 1908**

| | |
|---|---|
| Cylinders | 21" x 28" |
| Drivers, diam. | 63" |
| Steam pressure | 200 lb. |
| Grate area | 44 sq. ft. |
| Heating surface | 2348 sq. ft. |
| Weight on drivers | 152,000 lb. |
| " total engine | 206,000 lb. |
| Tractive force | 33,320 lb. |


| | |
|---|---|
| Cylinders | 24" x 30" |
| Drivers, diam. | 63" |
| Steam pressure | 200 lb. |
| Grate area | 48.8 sq. ft. |
| Heating surface | 3614 sq. ft. |
| Weight on drivers | 201,000 lb. |
| " total engine | 260,500 lb. |
| Tractive force | 46,630 lb. |

**Mikado Type Locomotive, Class L1, Built at the Milwaukee Shops, 1909**

in 1907. An additional 50 followed in 1908, and in the same year 20 were built at the Milwaukee Shops of the Railway Company. During the years 1908 and 1909, the Milwaukee Shops built 50 more and the American Locomotive Company an additional 25, making a total of 195 locomotives of this interesting class. Of these, somewhat more than one-third were subsequently fitted with superheaters.

To work in the mountain districts in conjunction with these locomotives, there were built at the Milwaukee Shops, in 1909, twenty locomotives of the Mikado (2–8–2) type, known as Class L1. These had the same size driving wheels as the Prairie type, a fourth pair of drivers being added, and the dimensions enlarged throughout to suit the increased hauling capacity thus provided. The firebox had the same length as that of the Prairie type, but its width was increased, and the grate area enlarged from 44 to 48.8 square feet. The other boiler dimensions were correspondingly increased.

There were very few Mikado type locomotives in service in 1909, and it is therefore interesting to note that these engines were particularly successful, establishing a general class that was subsequently built in large numbers. Forty locomotives of a class designated as L2, fitted with superheaters, but generally similar to Class L1, were built at Milwaukee in 1912; and 140 more were constructed by the American Locomotive Company during the years 1912 to 1914. These were, in turn, followed by 200 Baldwin locomotives (Classes L2-a and L2-b), built during the years 1920–1923. With the use of the superheater in the L2 group the cylinder dimensions were increased, raising the tractive force and reducing the ratio of adhesion to practically four. The original Mikados have also been superheated, but only two of them have been fitted with larger cylinders.

Before leaving the Mikado type locomotives, mention should be made of 100 Mikados of the so-called heavy U. S. R. A. design, which were built by the American Locomotive Company in 1918 and 1919, and assigned to the Milwaukee road. These locomotives, with larger boilers and increased tractive force as compared to their predecessors, have proved exceedingly serviceable on divisions where heavy tonnage


**Mikado Type Locomotive, Class L2-b, Built by The Baldwin Locomotive Works, 1923**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cylinders | 26" x 30" | Tubes, number | 5⅜", 34; 2", 198 | Wheel base, driving | 16' 6" | Weight, total engine | 292,770 lb. |
| Drivers, diam. | 63" | " length | 17' 6" | " " total engine | 35' 3" | " " " and | |
| Boiler, diam. | 77¾" | Grate area | 48.8 sq. ft. | " " " " and | | tender | 490,900 lb. |
| Steam pressure | 200 lb. | Water heating surface | 2924 sq. ft. | tender | 70' 6½" | Tank capacity | 10,000 U. S. gal. |
| Firebox | 107" x 65¾" | Superheating surface | 685 sq. ft. | Weight on drivers | 220,950 lb. | Fuel " | 16 tons |
| Tubes, diam. | 5⅜" & 2" | | | | | Tractive force | 54,720 lb. |

trains must be handled. They are known as Class L3.

Reference has been made to the fine work done on the heavy grades of the Puget Sound Extension by the Mikado type locomotives built in 1909. These were excellent road engines, but it soon became evident that heavier power was required, especially for pusher service on the Mountain divisions. Accordingly, 25 Mallet articulated compound locomotives, with the 2–6–6–2 wheel arrangement, were ordered from the American Locomotive Company. They were designated as Class N1, and were placed in service late in 1910 and early in 1911. These locomotives were designed to haul 900 tons at a speed of six to eight miles an hour on grades of 2.7 per cent. At the time of their construction, such grades had to be negotiated in crossing the Cascade Mountains, as the Snoqualmie Tunnel was not yet completed. Seventeen of the locomotives were fitted for burning coal, while the remaining eight, which were intended for use on divisions in the Idaho Forest Reserve, were equipped to burn oil.

These locomotives, as originally built, used saturated steam, and were fitted with piston valves on the high-pressure cylinders and slide valves on the low-pressure. A special feature was the use of a separate flexible exhaust pipe for each low-pressure cylinder, in order to provide a free exhaust and reduce back pressure on the low-pressure pistons.

The Class N1 locomotives proved successful in meeting the traffic requirements at that time, and eleven more of similar dimensions were built for the road by the American Locomotive Company in 1912. The new engines, designated as Class N2, were equipped with superheaters. With the present demand for increased speed in freight service, the Mallets are now being rebuilt with single expansion cylinders, which renders them more flexible and materially increases their capacity in ton-miles per hour. Further reference to this rebuilding will be made later.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|---|---|
| Cylinders | 27" x 32" |
| Drivers, diam. | 63" |
| Steam pressure | 190 lb. |
| Grate area | 70.5 sq. ft. |
| Water heating surface | 4311 sq. ft. |
| Superheating surface | 993 sq. ft. |
| Weight on drivers | 239,000 lb. |
| " total engine | 320,000 lb. |
| Tractive force | 59,800 lb. |

*Photo furnished by American Locomotive Co.*

**Mikado Type Locomotive, Class L3, Built by the American Locomotive Company, 1918**

| | |
|---|---|
| Cylinders | 23½" & 37" x 30" |
| Drivers, diam. | 57" |
| Steam pressure | 200 lb. |
| Grate area | 72 sq. ft. |
| Heating surface | 6555 sq. ft. |
| Weight on drivers | 323,500 lb. |
| " total engine | 390,000 lb. |
| Tractive force (compound) | 70,400 lb. |


*Photo furnished by American Locomotive Co.*

**Mallet Articulated Compound Locomotive, Class N1, Built by the American Locomotive Company, 1910**

Reverting now to power for passenger service, it will be remembered that an experimental locomotive of the Pacific (4-6-2) type was built at the Milwaukee Shops in 1905. This locomotive ranked as the heaviest six-coupled passenger engine on the line until 1910, when a new design of Pacific type, designated as Class F3, was introduced. The Atlantic type locomotives were becoming outclassed on the heaviest passenger trains, and Class F3 was designed to combine the speed capacity of the Atlantics with a substantial increase in hauling power. The Pacifics, as built, used saturated steam, and had driving wheels 79 inches in diameter, and cylinders measuring 23 by 28 inches. With


| | |
|---|---|
| Cylinders | 23" x 28" |
| Drivers, diam. | 79" |
| Steam pressure | 200 lb. |
| Grate area | 48.8 sq. ft. |
| Water heating surface | 2863 sq. ft. |
| Superheating surface | 620 sq. ft. |
| Weight on drivers | 157,200 lb. |
| " total engine | 247,300 lb. |
| Tractive force | 31,870 lb. |

Originally built to use saturated steam.

*Photo furnished by American Locomotive Co.*

**Pacific Type Locomotive, Class F3-s, Built by the American Locomotive Company, 1910**

a pressure of 200 pounds, the maximum tractive force was 31,870 pounds. The boiler was of the same diameter as that of the Class K1 Prairie type, while the grate was of the same dimensions as that of the Class L1 and L2 Mikado type locomotives. The design was so worked out that, where practicable, detail parts interchanged with those of the other classes.

A total of 70 locomotives of Class F3, were built for the road by the American Locomotive Company. They were followed, in 1910, by 20 locomotives of Class F4, which were built at the Milwaukee Shops. These locomotives had driving wheels 69 inches in diameter, and were intended for service on the mountain divisions. Otherwise they were of the same dimensions as Class F3. They were followed, in turn, by Class F5, of which 20 were built at Milwaukee during the years 1910-1912, and 50 by the American Locomotive Company in the year last named. Class F5 had 69-inch drivers, and was similar to Class F4, but used superheated steam.

Many of the Pacific type locomotives described above have undergone more or less rebuilding since they were originally constructed. Classes F3 and F4 have been fitted with superheaters, and, in some instances, with new cylinders of enlarged diameter. After the mountain sections had been electrified, the Class F4 and Class F5 locomotives were moved to the eastern lines. A large number of these locomotives had extra tires shrunk over the driving wheels, thus increasing the diameter of the latter to 73 inches.

All these Pacific type locomotives have rendered unusually fine service. Until the close of the year 1929, when The Baldwin Locomotive Works started to deliver a consignment of 4–6–4 type locomotives, they were the heaviest passenger locomotives on the line. Since they were built, the schedules of many through trains have been shortened, and train weights have increased due to the use of steel cars and the handling of de luxe equipment, such as lounge and observation cars. The old locomotives have met these increased demands successfully, maintaining an excellent "on time" performance with comparatively few engine failures. Well designed and built in the first place, they have been rebuilt and modernized, as far as has proved practicable, and have been well maintained and handled.

In 1929, the need of new power for handling through passenger service was becoming imperative, and 15 locomotives were ordered from The Baldwin Locomotive Works. The design of these locomotives was given unusually thorough consideration, with a view of furnishing power that would meet present-day requirements with a liberal margin to provide for a possible future increase in train loads. The most urgent need was for locomotives to meet the

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|---|---|
| Cylinders | 25" x 28" |
| Drivers, diam. | 69" |
| Steam pressure | 200 lb. |
| Grate area | 48.8 sq. ft. |
| Water heating surface | 2977 sq. ft. |
| Superheating surface | 620 sq. ft. |
| Weight on drivers | 160,000 lb. |
| " total engine | 253,000 lb. |
| Tractive force | 43,120 lb. |


*Photo furnished by American Locomotive Co.*

**Pacific Type Locomotive, Class F5-b, Built by the American Locomotive Company, 1912**


**4–6–4 Type Locomotive, Class F6, Built by The Baldwin Locomotive Works, 1929**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cylinders | 26″ x 28″ | Tubes, number | 3½″, 182; 2¼″, 58 | Wheel base, driving | 14′ 0″ | Weight, total engine | 375,850 lb. |
| Drivers, diam. | 79″ | " length | 19′ 0″ | " " total engine | 40′ 9″ | " " " and | |
| Boiler, diam. | 82″ | Grate area | 80 sq. ft. | " " " " and | | tender | 665,000 lb. |
| Steam pressure | 225 lb. | Water heating surface | 4205 sq. ft. | tender | 81′ 7½″ | Tank capacity | 15,000 U. S. gal. |
| Firebox | 120⅛″ x 96″ | Superheating surface | 1815 sq. ft. | Weight on drivers | 189,720 lb. | Fuel " | 20 tons |
| Tubes, diam. | 3½″ & 2¼″ | | | | | Tractive force | 45,820 lb. |

increasingly difficult requirements of the service between Chicago and Minneapolis, a run of 421 miles. The greater part of this distance is through rolling country, with undulating grades, reaching a maximum of 1.25 per cent. The problem was to design a locomotive which would meet definite weight limitations and be of sufficient horse-power capacity to maintain fast schedules with a reasonable maximum speed on descending grades. The line is double-tracked throughout its length and is protected by automatic signals of the upper quadrant type. Rails weighing 100 pounds to the yard are largely used, while some rails weighing 130 pounds have been placed in the track between Chicago and Milwaukee.

The 4–6–4 type was selected for this service, and the general features of the design are shown in the accompanying illustration of engine 6400. To carry a boiler of sufficient size, with a weight limit of approximately 63,000 pounds on each pair of driving wheels, necessitated the use of a four-wheeled rear truck, which in this instance is fitted with roller bearings.

The constructive details of these locomotives include a number of interesting features. A one-piece bed is used, with cylinders, frames, crossties, and front and back bumpers, constituting a single steel casting. This is an elaborate piece of work, designed to provide ample strength with minimum weight. The machinery details include Laird type crossheads and solid end stubs with floating bushings on all the crank pins. Fifty per cent of the reciprocating weight is balanced, and the revolving weights in the main wheels are cross-balanced.

The boiler has a conical course in the middle of the barrel, and a maximum outside diameter of 94 inches. The firebox and combustion chamber together provide a large furnace volume, and a heating surface of 307 square feet. A mechanical stoker is applied, the stoker engine being carried on


**4–8–4 Type Locomotive, Class S1, Built by The Baldwin Locomotive Works, 1930**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cylinders | 28″ x 30″ | Tubes, number | 3½″, 218; 2¼″, 56 | Wheel base, driving | 19′ 9″ | Weight, total engine | 450,840 lb. |
| Drivers, diam. | 74″ | " length | 21′ 0″ | " " total engine | 46′ 3″ | " " " and | |
| Boiler, diam. | 88″ | Grate area | 103 sq. ft. | " " " " and | | tender | 740,000 lb. |
| Steam pressure | 230 lb. | Water heating surface | 5400 sq. ft. | tender | 88′ 4½″ | Tank capacity | 15,000 U. S. gal. |
| Firebox | 137″ x 108¼″ | Superheating surface | 2403 sq. ft. | Weight on drivers | 258,810 lb. | Fuel " | 20 tons |
| Tubes, diam. | 3½″ & 2¼″ | | | | | Tractive force | 62,130 lb. |

the locomotive. The grates have circular air holes, and the air openings approximate 16 per cent of the grate area.

In addition to a type E superheater, the boiler accessories include a feed-water heater, front-end throttle, and smoke consumer, with three combustion tubes on each side of the firebox.

Fourteen locomotives as described above, designated as Class F6, are now in service and are doing excellent work. Thirteen are on the Chicago-Minneapolis run, going through without change in either direction, while the fourteenth is being tried out between Minneapolis and Harlowton, a distance of 914.4 miles. On this run there is also being tried out a 4–8–4 type locomotive, which was built to specifications similar to those covering the 4–6–4 type. Operating a coal-burning locomotive over a section of line which was formerly covered by seven engine divisions is a most interesting venture, and the new power promises to do the work successfully.

Roundup coal is burned west of Minneapolis. This is a semi-lignite of good quality, having a heating value in excess of 10,000 B. T. U. per pound. With a large area of netting in the smokebox, and round hole grates with about 16 per cent air opening, it is satisfactory for locomotive use, although it is liable to clinker if the locomotive is forced while carrying a heavy fire.

The 4–6–4 type locomotive of Class F6 is unquestionably able to maintain schedules on the Minneapolis-Harlowton run, but in view of the special conditions to be met, the 4–8–4 type is preferred. The greater part of this section of the line is located in fairly level country, although there is a gradual rise to the westward. Grades seldom exceed 0.6 per cent, and curves where they occur, are usually of two or three degrees. One of the hardest pulls is eastbound out of Marmarth, North Dakota, where the line rises 471 feet in a distance of 13.7 miles, the maximum grade being one per cent. But climatic conditions constitute a more serious handicap. During the winter months, heavy snows and intense cold are often encountered, and high winds are frequent at all seasons of the year. For these reasons a locomotive of ample capacity, that can handle the heaviest passenger trains without double-heading under adverse weather conditions, is specially desirable.

The 4–8–4 type locomotive, which is designated as Class S1, and bears the road number 9700, is shown in an accompanying illustration. Its design has many features in common with that of Class F6, and where practicable, the details of the two classes interchange. Both the front and back engine trucks of Class S1 are fitted with roller bearings. The firebox is unusually large, having a grate area of 103 square feet, and a heating surface, including the combustion chamber, of 407 square feet. The steaming capacity is ample for developing sustained horse-power on long runs.

Experience thus far indicates that locomotives of Classes F6 and S1 will be fully capable of meeting the passenger traffic requirements of the Milwaukee road for some time to come.

*This article will be concluded in the next issue.*