Baldwin Locomotive Works.

ILLUSTRATED CATALOGUE

OF

Narrow-Gauge Locomotives.

Adapted Especially to Gauges of 3 feet 6 inches or one metre.

BURNHAM, WILLIAMS & CO.

PHILADELPHIA, PA., U. S. A.

(Cable Address: BALDWIN, PHILADELPHIA.)

GEORGE BURNHAM,
WILLIAM P. HENSZEY,
JOHN H. CONVERSE.

WILLIAM L. AUSTIN,
SAMUEL M. VAUCLAIN,
ALBA B. JOHNSON,

GEORGE BURNHAM, Jr.

PRESS OF
GEORGE H. BUCHANAN AND COMPANY.

1900
PLAN.

THE BALDWIN LOCOMOTIVE WORKS is situated with a front on Broad Street, Philadelphia, extending from Pennsylvania Avenue to Spring Garden Street. It also comprises two blocks bounded by Fifteenth and Sixteenth, Hamilton and Spring Garden Streets, and the greater part of two blocks between Seventeenth and Eighteenth, and from Buttonwood Street to Pennsylvania Avenue. The plan below shows the area occupied, over fourteen acres in all, of which about eleven acres are under roof.

4. Iron Foundry and Repair Shop.
5. Superintendent’s Office, Laboratory, Pattern Shop, Electrical Department and Flange Shop.

NOTE.—The shaded places indicate buildings occupied by the Baldwin Locomotive Works.
THE BALDWIN LOCOMOTIVE WORKS dates its origin from the invention of steam railroads in America. Called into existence by the early requirements of the railroad interests of the country, it has grown with their growth and kept pace with their progress. It has reflected in its career the successive stages of American railroad practice, and has itself contributed largely to the development of the locomotive as it exists to-day. A history of the Baldwin Locomotive Works, therefore, is, in a great measure, a record of the progress of locomotive engineering in this country, and as such cannot fail to be of interest to those who are concerned in this important element of our material progress.

MATTHIAS W. BALDWIN, the founder of the establishment, learned the trade of a jeweller, and entered the service of Fletcher & Gardiner, Jewellers and Silversmiths, Philadelphia, in 1817. Two years later he opened a small shop, in the same line of business, on his own account. The demand for articles of this character falling off, however, he formed a partnership, in 1825, with David Mason, a machinist, in the manufacture of bookbinders' tools and cylinders for calico-printing. Their shop was in a small alley which runs north from Walnut Street, above Fourth. They afterwards removed to Minor Street, below Sixth. The business was so successful that steam-power became necessary in carrying on their manufactures, and an engine was bought for the purpose. This proving unsatisfactory, Mr. Baldwin decided to design and construct one which should be specially
adapted to the requirements of his shop. One of these requirements was that it should occupy the least possible space, and this was met by the construction of an upright engine on a novel and ingenious plan. On a bed-plate about five feet square an upright cylinder was placed; the piston-rod connected to a cross-bar having two legs, turned downward, and sliding in grooves on the sides of the cylinder, which thus formed the guides. To the sides of these legs, at their lower ends, was connected by pivots an inverted U-shaped frame, prolonged at the arch into a single rod, which took hold of the crank of a fly-wheel carried by upright standards on the bed-plate. It will be seen that the length of the ordinary separate guide-bars was thus saved, and the whole engine was brought within the smallest possible compass. The design of the machine was not only unique, but its workmanship was so excellent, and its efficiency so great, as readily to procure for Mr. Baldwin orders for additional stationary engines. His attention was thus turned to steam engineering, and the way was prepared for his grappling with the problem of the locomotive when the time should arrive.

This original stationary engine, constructed prior to 1830, is still in good order and carefully preserved at the Works. It has successively supplied the power in six different departments as they have been opened, from time to time, in the growth of the business.

The manufacture of stationary steam engines thus took a prominent place in the establishment, and Mr. Mason shortly afterwards withdrew from the partnership.

In 1829-30 the use of steam as a motive power on railroads had begun to engage the attention of American engineers. A few locomotives had been imported from England, and one (which, however, was not successful) had been constructed at the West Point Foundry, in New York City. To gratify the
public interest in the new motor, Mr. Franklin Peale, then proprietor of the Philadelphia Museum, applied to Mr. Baldwin to construct a minature locomotive for exhibition in his establishment. With the aid only of the imperfect published descriptions and sketches of the locomotives which had taken part in the Rainhill competition in England, Mr. Baldwin undertook the work, and on the 25th of April, 1831, the minature locomotive was put in motion on a circular track made of pine boards covered with hoop iron, in the rooms of the Museum. Two small cars, containing seats for four passengers, were attached to it, and the novel spectacle attracted crowds of admiring spectators. Both anthracite and pine-knot coal were used as fuel, and the exhaust steam was discharged into the chimney, thus utilizing it to increase the draught.

The success of the model was such that, in the same year, Mr. Baldwin received an order for a locomotive from the Philadelphia, Germantown and Norristown Railroad Company, whose short line of six miles to Germantown was operated by horsepower. The Camden and Amboy Railroad Company had shortly before imported a locomotive from England, which was stored in a shed at Bordentown. It had not yet been put together; but Mr. Baldwin, in company with his friend, Mr. Peale, visited the spot, inspected the detached parts, and made a few memoranda of some of its principal dimensions. Guided by these figures and his experience with the Peale model, Mr. Baldwin commenced the task. The difficulties to be overcome in filling the order can hardly be appreciated at this day. There were few mechanics competent to do any part of the work on a locomotive. Suitable tools were with difficulty obtainable. Cylinders were bored by a chisel fixed in a block of wood and turned by hand. Blacksmiths able to weld a bar of iron exceeding one and one-quarter inches in thickness were few, or not to be had. It was necessary for Mr. Baldwin to do much of the work with his own hands, to educate the workmen who assisted him, and to improvise tools for the various processes.

The work was prosecuted, nevertheless, under all these difficulties, and the locomotive was fully completed, christened the "Old Ironsides," and tried on the road, November 23, 1832.
The circumstances of the trial are fully preserved, and are given, farther on, in the extracts from the journals of the day. Despite some imperfections, naturally occurring in a first effort, and which were afterwards to a great extent remedied, the engine was, for that early day, a marked and gratifying success. It was put at once into service, as appears from the company's advertisement three days after the trial, and did duty on the Germantown road and others for over a score of years.

The "Ironsides" was a four-wheeled engine, modelled essentially on the English practice of that day, as shown in the "Planet" class, and weighed, in running order, something over five tons. The rear or driving-wheels were fifty-four inches in diameter on a crank-axle placed in front of the fire-box. The cranks were thirty-nine inches from centre to centre. The front wheels, which were simply carrying wheels, were forty-five inches in diameter, on an axle placed just back of the cylinders. The cylinders were nine and one-half inches in diameter by eighteen inches stroke, and were attached horizontally to the outside of the smoke-box, which was D-shaped, with the sides receding inwardly, so as to bring the centre line of each cylinder in line with the centre of the crank. The wheels were made with heavy cast-iron hubs, wooden spokes and rims, and wrought-iron tires. The frame was of wood, placed outside the wheels. The boiler
was thirty inches in diameter, and contained seventy-two copper flues, one and one-half inches in diameter and seven feet long. The tender was a four-wheeled platform, with wooden sides and back, carrying an iron box for a water-tank, inclosed in a wooden casing, and with a space for fuel in front. The engine had no cab. The valve-motion was at first given by a single loose eccentric for each cylinder, placed on the axle between the crank and the hub of the wheel. On the inside of the eccentric was a half-circular slot, running half-way around. A stop was fastened to the axle at the arm of the crank, terminating in a pin which projected into the slot. The engine was reversed by changing the position of the eccentric on the axle by a lever operated from the footboard. This form of valve-motion was, however, shortly afterwards changed, and a single fixed eccentric for each cylinder substituted. The rock-shafts, which were under the footboard, had arms above and below, and the eccentric-straips had each a forked rod, with a hook, or an upper and lower latch or pin, at their extremities, to engage with the upper or lower arm of the rock-shaft. The eccentric-rods were raised or lowered by a double treadle, so as to connect with the upper or lower arm of the rock-shaft, according as forward or backward gear was desired. A peculiarity in the exhaust of the "Ironsides" was that there was only a single straight pipe running across from one cylinder to the other, with an opening in the upper side of the pipe, midway between the cylinders, to which was attached at right angles the perpendicular pipe into the chimney. The cylinders, therefore, exhausted against each other; and it was found, after the engine had been put in use, that this was a serious objection. This defect was afterwards remedied by turning each exhaust-pipe upward into the chimney, substantially as is now done. The steam-joints were made with canvas and red-lead, as was the practice in English locomotives, and in consequence much trouble was caused, from time to time, by leaking.

The price of the engine was to have been $4,000, but some difficulty was found in procuring a settlement. The company claimed that the engine did not perform according to contract; and objection was also made to some of the defects alluded to.
After these had been corrected as far as possible, however, Mr. Baldwin finally succeeded in effecting a compromise settlement, and received from the Company $3500 for the machine.

The results of the trial and the impression produced by it on the public mind may be gathered from the following extracts from the newspapers of the day:

The *United States Gazette* of November 24, 1832, remarks:

"A most gratifying experiment was made yesterday afternoon on the Philadelphia, Germantown and Norristown Railroad. The beautiful locomotive engine and tender, built by Mr. Baldwin, of this city, whose reputation as an ingenious machinist is well known, were for the first time placed on the road. The engine traveled about six miles, working with perfect accuracy and ease in all its parts, and with great velocity."

The *Chronicle* of the same date noticed the trial more at length, as follows:

"It gives us pleasure to state that the locomotive engine built by our townsman, M. W. Baldwin, has proved highly successful. In the presence of several gentlemen of science and information on such subjects, the engine was yesterday placed upon the road for the first time. All her parts had been previously highly finished and fitted together in Mr. Baldwin's factory. She was taken apart on Tuesday, and removed to the Company's depot, and yesterday morning she was completely together, ready for travel. After the regular passenger cars had arrived from Germantown in the afternoon, the tracks being clear, preparation was made for her starting. The placing fire in the furnace and raising steam occupied twenty minutes. The engine (with her tender) moved from the depot in beautiful style, working with great ease and uniformity. She proceeded about half a mile beyond the Union Tavern, at the township line, and returned immediately, a distance of six miles, at a speed of about twenty-eight miles to the hour, her speed having been slackened at all the road crossings, and it being after dark, but a portion of her power was used. It is needless to say that the spectators were delighted. From this experiment there is every reason to believe this engine will draw thirty tons gross, at an average speed of forty miles an hour, on a level road. The principal superiority of the engine over any of the English ones known consists in the light weight,—which is but between four and five tons,—her small bulk, and the simplicity of her working machinery. We rejoice at the result of this experiment, as it conclusively shows that Philadelphia, always famous for the skill of her mechanics, is enabled to produce steam-engines for railroads combining so many superior qualities as to warrant the belief that her mechanics will hereafter supply nearly all the public works of this description in the country."

On subsequent trials, the "Ironsides" attained a speed of thirty miles per hour, with its usual train attached. So great were the wonder and curiosity which attached to such a prodigy, that
people flocked to see the marvel, and eagerly bought the privilege of riding after the strange monster. The officers of the road were not slow to avail themselves of the public interest to increase their passenger receipts, and the following advertisement from Poulson's American Daily Advertiser of November 26, 1832, will show that as yet they regarded the new machine rather as a curiosity and a bait to allure travel than as a practical everyday servant:

PHILADELPHIA, GERMANTOWN, AND NORRISTOWN RAIL-ROAD.

LOCOMOTIVE ENGINE.

NOTICE.—The Locomotive Engine, (built by M. W. Baldwin, of this city,) will depart DAILY, when the weather is fair, with a Train of Passenger Cars, commencing on Monday the 26th inst., at the following hours, viz—

FROM PHILADELPHIA.
At 11 o'clock, A. M. At 11 o'clock, A. M.
12 o'clock, M. M. 12 o'clock, M. M.
2 o'clock, P. M. 2 o'clock, P. M.

FROM GERMANTOWN.
At 12 o'clock, M. At 12 o'clock, M.
1 o'clock, P. M. 1 o'clock, P. M.
2 o'clock, P. M. 2 o'clock, P. M.

The Cars drawn by horses, will also depart as usual, from Philadelphia at 9 o'clock, A. M., and from Germantown at 10 o'clock, A. M., and at the above mentioned hours when the weather is not fair.
The points of starting, are from the Depot, at the corner of Green and Ninth street, Philadelphia, and from the Main street, near the centre of Germantown. Whole Cars can be taken. Tickets, 25 cents.

This announcement did not mean that in wet weather horses would be attached to the locomotive to aid it in drawing the train, but that the usual horse cars would be employed in making the trips upon the road without the engine.

Upon making the first trip to Germantown with a passenger train with the "Ironsides," one of the drivers slipped upon the axle, causing the wheels to track less than the gauge of the road and drop in between the rails. It was also discovered that the valve arrangement of the pumps was defective, and they failed to supply the boiler with water. The shifting of the driving-wheel upon the axle fastened the eccentric, so that it would not operate in backward motion. These mishaps caused delay, and
prevented the engine from reaching its destination, to the great
disappointment of all concerned. They were corrected in a few
days, and the machine was used in experimenting upon its
efficiency, making occasional trips with trains to Germantown.
The road had an ascending grade, nearly uniform, of thirty-two
feet per mile, and for the last half-mile of forty-five feet per mile,
and it was found that the engine was too light for the business
of the road upon these grades.

Such was Mr. Baldwin’s first locomotive; and it is related of
him that his discouragement at the difficulties which he had
undergone in building it, and in finally procuring a settlement for
it, was such that he remarked to one of his friends, with much
decision, “That is our last locomotive.”

It was some time before he received an order for another, but
meanwhile the subject had become singularly fascinating to him,
and occupied his mind so fully that he was eager to work out his
new ideas in a tangible form.

Shortly after the “Ironsides” had been placed on the German-
town road, Mr. E. L. Miller, of Charleston, S. C., came to
Philadelphia and made a careful examination of
the machine. Mr. Miller had, in 1830, contracted
to furnish a locomotive to the Charleston and
Hamburg Railroad Company, and accordingly
the engine “Best Friend” had been built under
his direction at the West Point Foundry, New
York. After inspecting the “Ironsides,” he sug-
gested to Mr. Baldwin to visit the Mohawk and
Hudson Railroad, and examine an English loco-
motive which had been placed on that road in
of Newcastle, England. It was originally a four-
wheeled engine of the “Planet” type, with hori-
izontal cylinders and crank-axle. The front wheels of this engine
were removed about a year after the machine was put at work,
and a four-wheeled swiveling or “bogie” truck substituted. The
result of Mr. Baldwin’s investigations was the adoption of this
design, but with some important improvements. Among these
was the “half-crank,” which he devised on his return from this
trip, and which he patented September 10, 1834. In this form of crank, the outer arm is omitted, and the wrist is fixed in a spoke of the wheel. In other words, the wheel itself formed one arm of the crank. The result sought and gained was that the cranks were strengthened, and, being at the extremities of the axle, the boiler could be made larger in diameter and placed lower. The driving-axle could also be placed back of the fire-box; the connecting-rods passing by the sides of the fire-box and taking hold inside of the wheels. This arrangement of the crank also involved the placing of the cylinders outside the smoke-box, as was done on the "Ironsides."

By the time the order for the second locomotive was received, Mr. Baldwin had matured this device and was prepared to embody it in practical form. The order came from Mr. E. L. Miller in behalf of the Charleston and Hamburg Railroad Company, and the engine bore his name, and was completed February 18, 1834. It was on six wheels; one pair being drivers, four and a half feet in diameter, with half-crank axle placed back of the fire-box as above described, and the four front wheels combined in a swivelling truck. The driving-wheels, it should be observed, were cast in solid bell-metal! The combined wood and iron wheels used on the "Ironsides" had proved objectionable, and Mr. Baldwin, in his endeavors to find a satisfactory substitute, had recourse to brass. June 29, 1833, he took out a patent for a cast-brass wheel, his idea being that by varying the hardness of the metal the adhesion of the drivers on the rails could be increased or diminished at will. The brass wheels on the "Miller," however, soon wore out, and the experiment with this metal was not repeated. The "E. L. Miller" had cylinders ten inches in diameter; stroke of piston, sixteen inches; and weighed, with water in the boiler, seven tons eight hundred-
weight. The boiler had a high dome over the fire-box; and this form of construction, it may be noted, was followed, with a few exceptions, for many years.

The valve-motion was given by a single fixed eccentric for each cylinder. Each eccentric-strap had two arms attached to it, one above and the other below, and, as the driving-axle was back of the fire-box, these arms were prolonged backward under the footboard, with a hook on the inner side of the end of each. The rock-shaft had arms above and below its axis, and the hooks of the two rods of each eccentric were moved by hand-levers so as to engage with either arm, thus producing backward or forward gear. This form of single eccentric, peculiar to Mr. Baldwin, was in the interest of simplicity in the working parts, and was adhered to for some years. It gave rise to an animated controversy among mechanics as to whether, with its use, it was possible to get a lead on the valve in both directions. Many maintained that this was impracticable; but Mr. Baldwin demonstrated by actual experience that the reverse was the case.

Meanwhile, the Commonwealth of Pennsylvania had given Mr. Baldwin an order for a locomotive for the State Road, as it was then called, from Philadelphia to Columbia, which, up to that time, had been worked by horses. This engine, called the “Lancaster,” was completed in June, 1834. It was similar to the “Miller,” and weighed seventeen thousand pounds. After it was placed in service, the records show that it hauled at one time nineteen loaded burden cars over the highest grades between Philadelphia and Columbia. This was characterized at the time by the officers of the road as an “unprecedented performance.” The success of the machine on its trial trips was such that the Legislature decided to adopt steam-power for working the road, and Mr. Baldwin received orders for several additional locomotives. Two others were accordingly delivered to the State in September and November respectively of that year, and one was also built and delivered to the Philadelphia and Trenton Railroad Company during the same season. This latter engine, which was put in service October 21, 1834, averaged twenty-one thousand miles per year to September 15, 1840.

Five locomotives were thus completed in 1834, and the new
business was fairly under way. The building in Lodge Alley, to which Mr. Baldwin had removed from Minor Street, and where these engines were constructed, began to be found too contracted, and another removal was decided upon. A location on Broad and Hamilton Streets (the site, in part, of the present works) was selected, and a three-story L-shaped brick building, fronting

Baldwin Compound Wood and Iron Wheels, 1834.

on both streets, erected. This was completed and the business removed to it during the following year (1835). The original building was partially destroyed by fire in 1884, and was replaced by a four-story brick structure.

These early locomotives, built in 1834, were the types of Mr. Baldwin's practice for some years. All, or nearly all of them,
embraced several important devices, which were the results of his study and experiments up to that time. The devices referred to were patented September 10, 1834, and the same patent covered the following four inventions, viz.:

1. The half-crank, and method of attaching it to the driving-wheel. (This has already been described.)

2. A new mode of constructing the wheels of locomotive engines and cars. In this the hub and spokes were of cast iron, cast together. The spokes were cast without a rim, and terminated in segment flanges, each spoke having a separate flange disconnected from its neighbors. By this means, it was claimed, the injurious effect of the unequal expansion of the materials composing the wheels was lessened or altogether prevented. The flanges bore against wooden felloes, made in two thicknesses, and put together so as to break joints. Tenons or pins projected from the flanges into openings made in the wooden felloes, to keep them in place. Around the whole the tire was passed and secured by bolts. The sketch on page 17 shows the device.

3. A new mode of forming the joints of steam and other tubes. This was Mr. Baldwin's invention of ground joints for steam-pipes, which was a very valuable improvement over previous methods of making joints with red-lead packing, and which rendered it possible to carry a much higher pressure of steam.

4. A new mode of forming the joints and other parts of the supply-pump, and of locating the pump itself. This invention consisted in making the single guide-bar hollow and using it for the pump-barrel. The pump-plunger was attached to the piston-rod at a socket or sleeve formed for the purpose, and the hollow guide-bar terminated in the vertical pump-chamber. This chamber was made in two pieces, joined about midway between the induction and eduction pipes. This joint was ground steam-tight, as were also the joints of the induction-pipe with the bottom of the lower chamber, and the flange of the eduction-pipe with the top of the upper chamber. All these parts were held together by a stirrup with a set-screw in its arched top, and the arrangement was such that by simply unscrewing this set-screw the
different sections of the chamber, with all the valves, could be taken apart for cleaning or adjusting. The cut below illustrates the device.

It is probable that the five engines built during 1834 embodied all, or nearly all, these devices. They all had the half-crank, the ground joints for steam-pipes (which were first made by him in 1833), and the pump formed in the guide-bar, and all had the four-wheeled truck in front, and a single pair of drivers back of the fire-box. On this position of the driving-wheels Mr. Baldwin laid great stress, as it made a more even distribution of the weight, throwing about one-half on the drivers and one-half on the four-wheeled truck. It also extended the wheel-base, making the engine much steadier and less damaging to the track. Mr. William Norris, who had established a locomotive works in Philadelphia in 1832, was at this time building a six-wheeled engine with a truck in front and the driving-wheels placed in front of the fire-box. Considerable rivalry naturally existed between the two manufacturers as to the comparative merits of their respective plans. In Mr. Norris's engine, the position of the driving-axle in front of the fire-box threw on it more of the
weight of the engine, and thus increased the adhesion and the tractive power. Mr. Baldwin, however, maintained the superiority of his plan, as giving a better distribution of the weight and a longer wheel-base, and consequently rendering the machine less destructive to the track. As the iron rails then in use were generally light, and much of the track was of wood, this feature was of some importance.

To the use of the ground joint for steam-pipes, however, much of the success of his early engines was due. The English builders were making locomotives with canvas and red-lead joints, permitting a steam pressure of only sixty pounds per inch to be carried, while Mr. Baldwin's machines were worked at one hundred and twenty pounds with ease. Several locomotives imported from England at about this period by the Commonwealth of Pennsylvania for the State Road (three of which were made by Stephenson) had canvas and red-lead joints, and their efficiency was so much less than that of the Baldwin engines, on account of this and other features of construction, that they were soon laid aside or sold.

In June, 1834, a patent was issued to Mr. E. L. Miller, by whom Mr. Baldwin's second engine was ordered, for a method of increasing the adhesion of a locomotive by throwing a part of the weight of the tender on the rear of the engine, thus increasing the weight on the drivers. Mr. Baldwin adopted this device on an engine built for the Philadelphia and Trenton Railroad Company, May, 1835, and thereafter used it largely, paying one hundred dollars royalty for each engine. Eventually (May 6, 1839,) he bought the patent for nine thousand dollars, evidently considering that the device was especially valuable, if not indispensable, in order to render his engine as powerful, when required, as other patterns having the driving-wheels in front of the fire-box, and therefore utilizing more of the weight of the engine for adhesion.

In making the truck and tender-wheels of these early locomotives, the hubs were cast in three pieces and afterwards banded with wrought-iron, the interstices being filled with spelter. This method of construction was adopted on account of the difficulty then found in casting a chilled wheel in one solid piece.
Early in 1835, the new shop on Broad Street was completed and occupied. Mr. Baldwin's attention was thenceforward given to locomotive building exclusively, except that a stationary engine was occasionally constructed.

In May, 1835, his eleventh locomotive, the "Black Hawk," was delivered to the Philadelphia and Trenton Railroad Company. This was the first outside-connected engine of his build. It was also the first engine on which the Miller device of attaching part of the weight of the tender to the engine was employed. On the eighteenth engine, the "Brandywine," built for the Philadelphia and Columbia Railroad Company, brass tires were used on the driving-wheels, for the purpose of obtaining more adhesion; but they wore out rapidly and were replaced with iron.

April 3, 1835, Mr. Baldwin took out a patent for certain improvements in the wheels and tubes of locomotive engines. That relating to the wheels provided for casting the hub and spokes together, and having the spokes terminate in segments of a rim, as described in his patent of September 10, 1834. Between the ends of the spokes and the tires, wood was interposed, and the tire might be either of wrought-iron or of chilled cast-iron. The intention was expressed of making the tire usually of cast-iron chilled. The main object, however, was declared to be the interposition between the spokes and the rim of a layer of wood or other substance possessing some degree of elasticity. This method of making driving-wheels was followed for several years, the tires being made with a shoulder. See illustration on page 22.

The improvement in locomotive tubes consisted in driving a copper ferrule or thimble on the outside of the end of the tube, and soldering it in place, instead of driving a ferrule into the tube, as had previously been the practice. The object of the latter method had been to make a tight joint with the tube-sheet; but by putting the ferrule on the outside of the tube, not only was the joint made as tight as before, but the tube was strengthened, and left unobstructed throughout to the full extent of its diameter. This method of setting flues has been generally followed in the works from that date to the present, the only difference being that, at this time, with iron tubes, the end is
swedged down, the copper ferrule brazed on, and the iron end turned or riveted over against the copper thimble and the fluesheet, to make the joint perfect.

**Driving Wheels, Patented September, 1834.**

Fourteen engines were constructed in 1835; forty in 1836; forty in 1837; twenty-three in 1838; twenty-six in 1839; and nine in 1840. During all these years the general design continued the same; but, in compliance with the demand for more power, three sizes were furnished, as follows:

- **First class. Cylinders, 12½ × 16; weight, loaded, 26,000 pounds.**
- **Second class. “ 12 × 16; “ 24,000 “**
- **Third class. “ 10½ × 16; “ 20,000 “**

The first-class engine he fully believed, in 1838, was as heavy as would be called for, and he declared that it was as large as he intended to make. Most of the engines were built with the half-crank, but occasionally an outside-connected machine was turned out. These latter, however, failed to give as complete satisfaction as the half-crank machine. The drivers were generally four and a half feet in diameter.
A patent was issued to Mr. Baldwin, August 17, 1835, for his device of cylindrical pedestals. In this method of construction, the pedestal was of cast-iron, and was bored in a lathe so as to form two concave jaws. The boxes were also turned in a lathe so that their vertical ends were cylindrical, and they were thus fitted in the pedestals. This method of fitting up pedestals and boxes was cheap and effective, and was used for some years for the driving and tender wheels.

As showing the estimation in which these early engines were held, it may not be out of place to refer to the opinions of some of the railroad managers of that period.

Mr. L. A. Sykes, engineer of the New Jersey Transportation Company, under date of June 12, 1838, wrote that he could draw with his engines twenty four-wheeled cars with twenty-six passengers each, at a speed of twenty to twenty-five miles per hour, over grades of twenty-six feet per mile. "As to simplicity of construction," he adds, "small liability to get out of order, economy of repairs, and ease to the road, I fully believe Mr. Baldwin's engines stand unrivalled. I consider the simplicity of the engine, the arrangement of the working parts, and the distribution of the weight, far superior to any engine I have ever seen, either of American or English manufacture, and I have not the least hesitation in saying, that Mr. Baldwin's engine will do the same amount of work with much less repairs, either to the engine or the track, than any other engine in use."

L. G. Cannon, President of the Rensselaer and Saratoga Railroad Company, writes: "Your engines will, in performance and cost of repairs, bear comparison with any other engine made in this or any other country."

Some of Mr. Baldwin's engines on the State Road, in 1837, cost, for repairs, only from one and two-tenths to one and six-tenths cents per mile. It is noted that the engine "West Chester," on the same road, weighing twenty thousand seven hundred and thirty-five pounds (ten thousand four hundred and seventy-five on drivers), drew fifty-one cars (four-wheeled), weighing two hundred and eighty-nine net tons, over the road, some of the track being of wood covered with strap-rail.

The financial difficulties of 1836 and 1837, which brought
ruin upon so many, did not leave Mr. Baldwin unscathed. His embarrassments became so great that he was unable to proceed, and was forced to call his creditors together for a settlement. After offering to surrender all his property, his shop, tools, house, and everything, if they so desired,—all of which would realize only about twenty-five per cent. of their claims,—he proposed to them that they should permit him to go on with the business, and in three years he would pay the full amount of all claims, principal and interest. This was finally acceded to, and the promise was in effect fulfilled, although not without an extension of two years beyond the time originally proposed.

In May, 1837, the number of hands employed was three hundred, but this number was reducing weekly, owing to the falling off in the demand for engines.

These financial troubles had their effect on the demand for locomotives, as will be seen in the decrease in the number built in 1838, 1839, and 1840; and this result was furthered by the establishment of several other locomotive works, and the introduction of other patterns of engines.

The changes and improvements in details made during these years may be summed up as follows:

The subject of burning anthracite coal had engaged much attention. In October, 1836, Mr. Baldwin secured a patent for a grate or fireplace which could be detached from the engine at pleasure, and a new one with a fresh coal fire substituted. The intention was to have the grate with freshly ignited coal all ready for the engine on its arrival at a station, and placed between the rails over suitable levers, by which it could be attached quickly to the fire-box. It is needless to say that this was never practised. In January, 1838, however, Mr. Baldwin was experimenting with the consumption of coal on the Germantown road, and in July of the same year the records show that he was making a locomotive to burn coal, part of the arrangement being to blow the fire with a fan.

Up to 1838, Mr. Baldwin had made both driving and truck wheels with wrought tires, but during that year chilled wheels for engine and tender trucks were adopted. His tires were furnished by Messrs. S. Vail & Son, Morristown, N. J., who
made the only tires then obtainable in America. They were very thin, being only one inch to one and a half inches thick; and Mr. Baldwin, in importing some tires from England at that time, insisted on their being made double the ordinary thickness. The manufacturers at first objected and ridiculed the idea, the practice being to use two tires when extra thickness was wanted, but finally they consented to meet his requirements.

All his engines thus far had the single eccentric for each valve, but at about this period double eccentrics were adopted, each terminating in a straight hook, and reversed by hand-levers.

At this early period, Mr. Baldwin had begun to feel the necessity of making all like parts of locomotives of the same class in such manner as to be absolutely interchangeable. Steps were taken in this direction, but it was not until many years afterwards that the system of standard gauges was perfected, which has since grown to be a distinguishing feature in the establishment.

In March, 1839, Mr. Baldwin’s records show that he was building a number of outside-connected engines, and had succeeded in making them strong and durable. He was also making a new chilled wheel, and one which he thought would not break.

On the one hundred and thirty-sixth locomotive, completed October 18, 1839, for the Philadelphia, Germantown and Norristown Railroad, the old pattern of wooden frame was abandoned, and no outside frame whatever was employed,—the machinery, as well as the truck and the pedestals of the driving-axles, being attached directly to the naked boiler. The wooden frame thenceforward disappeared gradually, and an iron frame took its place. Another innovation was the adoption of eight-wheeled tenders, the first of which was built at about this period.

April 8, 1839, Mr. Baldwin associated with himself Messrs. Vail & Hufty, and the business was conducted under the firm name of Baldwin, Vail & Hufty until 1841, when Mr. Hufty withdrew, and Baldwin & Vail continued the copartnership until 1842.

The time had now arrived when the increase of business on railroads demanded more powerful locomotives. It had for some years been felt that for freight traffic the engine with one pair of
drivers was insufficient. Mr. Baldwin’s engine had the single pair of drivers placed back of the fire-box; that made by Mr. Norris, one pair in front of the fire-box. An engine with two pairs of drivers, one pair in front and one pair behind the fire-box, was the next logical step, and Mr. Henry R. Campbell, of Philadelphia, was the first to carry this design into execution. Mr. Campbell, as has been noted, was the Chief Engineer of the Germantown Railroad when the “Ironsides” was placed on that line, and had since given much attention to the subject of locomotive construction. February 5, 1836, Mr. Campbell secured a patent for an eight-wheeled engine with four drivers connected, and a four-wheeled truck in front; and subsequently contracted with James Brooks, of Philadelphia, to build for him such a machine. The work was begun March 16, 1836, and the engine was completed May 8, 1837. This was the first eight-wheeled engine of this type, and from it the standard American locomotive of to-day takes its origin. The engine lacked, however, one essential feature; there were no equalizing beams between the drivers, and nothing but the ordinary steel springs over each journal of the driving axles to equalize the weight upon them. It remained for Messrs. Eastwick & Harrison to supply this deficiency; and in 1837 that firm constructed at their shop in Philadelphia, a locomotive on this plan, but with the driving-axles running in a separate square frame, connected to the main frame above it by a single central bearing on each side. This engine had cylinders twelve by eighteen, four coupled driving-wheels, forty-four inches in diameter, carrying eight of the twelve tons constituting the total weight. Subsequently, Mr. Joseph Harrison, Jr., of the same firm, substituted “equalizing beams” on engines of this plan afterwards constructed by them, substantially in the same manner as since generally employed.

In the American Railroad Journal of July 30, 1836, a wood-cut showing Mr. Campbell’s engine, together with an elaborate calculation of the effective power of an engine on this plan, by William J. Lewis, Esq., Civil Engineer, was published, with a table showing its performance upon grades ranging from a dead level to a rise of one hundred feet per mile. Mr. Campbell stated that his experience at that time (1835-36) convinced him
that grades of one hundred feet rise per mile would, if roads were judiciously located, carry railroads over any of the mountain passes in America, without the use of planes with stationary steam power, or, as a general rule, of costly tunnels,—an opinion very extensively verified by the experience of the country since that date.

A step had thus been taken towards a plan of locomotive having more adhesive power. Mr. Baldwin, however, was slow to adopt the new design. He naturally regarded innovations with distrust. He had done much to perfect the old pattern of engine, and had built over a hundred of them, which were in successful operation on various railroads. Many of the details were the subjects of his several patents, and had been greatly simplified in his practice. In fact, simplicity in all the working parts had been so largely his aim, that it was natural that he should distrust any plan involving additional machinery, and he regarded the new design as only an experiment at best. In November, 1838, he wrote to a correspondent that he did not think there was any advantage in the eight-wheeled engine. There being three points in contact, it could not turn a curve, he argued, without slipping one or the other pair of wheels sideways. Another objection was in the multiplicity of machinery and the difficulty in maintaining four driving-wheels all of exactly the same size. Some means, however, of getting more adhesion must be had, and the result of his reflections upon this subject was the project of a "geared engine." In August, 1839, he took steps to secure a patent for such a machine, and December 31, 1840, letters patent were granted him for the device. In this engine, an independent shaft or axle was placed between the two axles of the truck, and connected by cranks and coupling-rods with cranks on the outside of the driving-wheels. This shaft had a central cog-wheel engaging on each side with intermediate cog-wheels, which in turn geared into cog-wheels on each truck-axle. The intermediate cog-wheels had wide teeth, so that the truck could pivot while the main shaft remained parallel with the driving-axle. The diameters of the cog-wheels were, of course, in such proportion to the driving- and truck-wheels that the latter should revolve as much oftener
than the drivers as their smaller size might require. Of the success of this machine for freight service, Mr. Baldwin was very sanguine. One was put in hand at once, completed in August, 1841, and eventually sold to the Sugarloaf Coal Company. It was an outside-connected engine, weighing thirty thousand pounds, of which eleven thousand seven hundred and seventy-five pounds were on the drivers, and eighteen thousand three hundred and thirty-five on the truck. The driving-wheels were forty-four and the truck-wheels thirty-three inches in diameter. The cylinders were thirteen inches in diameter by sixteen inches stroke. On a trial of the engine upon the Philadelphia and Reading Railroad, it hauled five hundred and ninety tons from Reading to Philadelphia—a distance of fifty-four miles—in five hours and twenty-two minutes. The Superintendent of the road, in writing of the trial, remarked that this train was unprecedented in length and weight both in America and Europe. The performance was noticed in favorable terms by the Philadelphia newspapers, and was made the subject of a report by the Committee on Science and Arts of the Franklin Institute, who strongly recommended this plan of engine for freight service. The success of the trial led Mr. Baldwin at first to believe that the geared engine would be generally adopted for freight traffic; but in this he was disappointed. No further demand was made for such machines, and no more of them were built.

In 1840, Mr. Baldwin received an order, through August Belmont, Esq., of New York, for a locomotive for Austria, and had nearly completed one which was calculated to do the work required, when he learned that only sixty pounds pressure of steam was admissible, whereas his engine was designed to use steam at one hundred pounds and over. He accordingly constructed another, meeting this requirement, and shipped it in the following year. This engine, it may be noted, had a kind of link-motion, agreeably to the specification received, and was the first of his make upon which the link was introduced.

Mr. Baldwin's patent of December 31, 1840, already referred to as covering his geared engine, embraced several other devices, as follows:

1. A method of operating a fan, or blowing-wheel, for the
purpose of blowing the fire. The fan was to be placed under the footboard, and driven by the friction of a grooved pulley in contact with the flange of the driving-wheel.

2. The substitution of a metallic stuffing, consisting of wire, for the hemp, wool, or other material which had been employed in stuffing-boxes.

3. The placing of the springs of the engine truck so as to obviate the evil of the locking of the wheels when the truck-frame vibrates from the centre-pin vertically. Spiral as well as semi-elliptic springs, placed at each end of the truck-frame, were specified. The spiral spring is described as received in two cups, —one above and one below. The cups were connected together at their centres, by a pin upon one and a socket in the other, so that the cups could approach towards or recede from each other and still preserve their parallelism.

4. An improvement in the manner of constructing the iron frames of locomotives, by making the pedestals in one piece with and constituting part of, the frames.

5. The employment of spiral springs in connection with cylindrical pedestals and boxes. A single spiral was at first used, but, not proving sufficiently strong, a combination or nest of spirals curving alternately in opposite directions was afterwards employed. Each spiral had its bearing in a spiral recess in the pedestal.

In the specification of this patent a change in the method of making cylindrical pedestals and boxes is noted. Instead of boring and turning them in a lathe, they were cast to the required shape in chills. This method of construction was used for a time, but eventually a return was made to the original plan, as giving a more accurate job.

In 1842, Mr. Baldwin constructed, under an arrangement with Mr. Ross Winans, three locomotives for the Western Railroad of Massachusetts, on a plan which had been designed by that gentleman for freight traffic. These machines had upright boilers, and horizontal cylinders which worked cranks on a shaft bearing cog-wheels engaging with other cog-wheels on an intermediate shaft. This latter shaft had cranks coupled to four driving-wheels on each side. These engines were constructed
to burn anthracite coal. Their peculiarly uncouth appearance earned for them the name of "crabs," and they were but short lived in service.

But to return to the progress of Mr. Baldwin’s locomotive practice. The geared engine had not proved a success. It was unsatisfactory, as well to its designer as to the railroad com-

Baldwin Six-Wheels-Connected Engine, 1847.

munity. The problem of utilizing more or all of the weight of the engine for adhesion remained, in Mr. Baldwin’s view, yet to be solved. The plan of coupling four or six wheels had long before been adopted in England, but on the short curves prevalent on American railroads he felt that something more was necessary. The wheels must not only be coupled, but at the same time must be free to adapt themselves to a curve. These two conditions were apparently incompatible, and to reconcile these inconsistencies was the task which Mr. Baldwin set himself to accomplish. He undertook it, too, at a time when his business had
fallen off greatly and he was involved in the most serious financial embarrassments. The problem was constantly before him, and at length, during a sleepless night, its solution flashed across his mind. The plan so long sought for, and which, subsequently,

more than any other of his improvements or inventions, contributed to the foundation of his fortune, was his well-known six-wheels-connected locomotive with the four front drivers combined in a flexible truck. For this machine Mr. Baldwin secured a patent, August 25, 1842. Its principal characteristic features are now matters of history, but they deserve here a brief mention. The engine was on six wheels, all connected as drivers. The rear wheels were placed rigidly in the frames, usually behind the fire-box, with inside bearings. The cylinders were inclined, and with outside connections. The four remaining wheels had inside journals running in boxes held by two wide and deep wrought-iron beams, one on each side. These beams were unconnected, and entirely independent of each other. The pedestals formed in them were bored out cylindrically, and into them cylindrical boxes, as patented by him in 1835, were fitted. The engine frame on each side was directly over the beam, and a spherical pin, running down from the frame, bore in a socket in the beam midway between the two axles. It will thus be seen that each side-beam independently could turn horizontally or vertically under the spherical pin, and the cylindrical boxes could also turn in the pedestals. Hence, in passing a curve, the middle pair of drivers could move laterally in one direction—say to the right—while the front pair could move in the opposite direction, or to the left; the two axles all the while remaining parallel to each other and to the rear driving-axle. The operation of these beams was, therefore, like that of the parallel-ruler. On a straight line the
two beams and the two axles formed a rectangle; on curves, a parallelogram, the angles varying with the degree of curvature. The coupling-rods were made with cylindrical brasses, thus forming ball-and-socket joints, to enable them to accommodate themselves to the lateral movements of the wheels. Colburn, in his "Locomotive Engineering," remarks of this arrangement of rods as follows:

"Geometrically, no doubt, this combination of wheels could only work properly around curves by a lengthening and shortening of the rods which served to couple the principal pair of driving-wheels with the hind truck-wheels. But if the coupling-rods from the principal pair of driving-wheels be five feet long, and if the beams of the truck-frame be four feet long (the radius of curve described by the axle-boxes around the spherical side bearings being two feet), then the total corresponding lengthening of the coupling-rods, in order to allow the hind truck-wheels to move one inch to one side, and the front wheels of the truck one inch to the other side of their normal position on a straight line, would be \( \sqrt{60^2 + 1^2} - 60 + 24 = \sqrt{24^2} - 1^2 = 0.0275 \) inch, or less than one thirty-second of an inch. And if only one pair of driving-wheels were thus coupled with a four-wheeled truck, the total wheel-base being nine feet, the motion permitted by this slight elongation of the coupling-rods (an elongation provided for by a trifling slackness in the brasses) would enable three pairs of wheels to stand without binding in a curve of only one hundred feet radius."

The first engine of the new plan was finished early in December, 1842, being one of fourteen engines constructed in that year, and was sent to the Georgia Railroad, on the order of Mr. J. Edgar Thomson, then Chief Engineer and Superintendent of that line. It weighed twelve tons, and drew, besides its own weight, two hundred and fifty tons up a grade of thirty-six feet to the mile.

Other orders soon followed. The new machine was received generally with great favor. The loads hauled by it exceeded anything so far known in American railroad practice, and sagacious managers hailed it as a means of largely reducing operating expenses. On the Central Railroad of Georgia, one of these twelve-ton engines drew nineteen eight-wheeled cars, with seven hundred and fifty bales of cotton, each bale weighing four hundred and fifty pounds, over maximum grades of thirty feet per mile, and the manager of the road declared that it could readily take one thousand bales. On the Philadelphia and Reading Railroad a similar engine of eighteen tons weight drew one hundred
and fifty loaded cars (total weight of cars and lading, one thousand one hundred and thirty tons) from Schuylkill Haven to Philadelphia, at a speed of seven miles per hour. The regular load was one hundred loaded cars, which were hauled at a speed of from twelve to fifteen miles per hour on a level.

The following extract from a letter, dated August 10, 1844, of Mr. G. A. Nicolls, then superintendent of that line, gives the particulars of the performance of these machines, and shows the estimation in which they were held:

"We have had two of these engines in operation for about four weeks. Each engine weighs about forty thousand pounds with water and fuel, equally distributed on six wheels, all of which are coupled, thus gaining the whole adhesion of the engine's weight. Their cylinders are fifteen by eighteen inches.

"The daily allotted load of each of these engines is one hundred coal cars, each loaded with three and six-tenths tons of coal, and weighing two and fifteen one-hundredths tons each, empty; making a net weight of three hundred and sixty tons of coal carried, and a gross weight of train of five hundred and seventy-five tons, all of two thousand two hundred and forty pounds.

"This train is hauled over the ninety-four miles of the road, half of which is level, at the rate of twelve miles per hour; and with it the engine is able to make fourteen to fifteen miles per hour on a level.

"Were all the cars on the road of sufficient strength, and making the trip by daylight, nearly one-half being now performed at night, I have no doubt of these engines being quite equal to a load of eight hundred tons gross, as their average daily performance on any of the levels of our road, some of which are eight miles long.

"In strength of mike, quality of workmanship, finish, and proportion of parts, I consider them equal to any, and superior to most, freight engines I have seen. They are remarkably easy on the rail, either in their vertical or horizontal action, from the equalization of their weight, and the improved truck under the forward part of the engine. This latter adapts itself to all the curves of the road, including some of seven hundred and sixteen feet radius in the main track, and moves with great ease around our turning γ curves at Richmond, of about three hundred feet radius.

"I consider these engines as near perfection, in the arrangement of their parts, and their general efficiency, as the present improvements in machinery and the locomotive engine will admit of. They are saving us thirty per cent. in every trip on the former cost of motive or engine power."

But the flexible-beam truck also enabled Mr. Baldwin to meet the demand for an engine with four drivers connected. Other builders were making engines with four drivers and a four-wheeled truck, of the present American standard type. To compete with this design, Mr. Baldwin modified his six-wheels-
connected engine by connecting only two out of the three pairs of wheels as drivers, making the forward wheels of smaller diameter as leading wheels, but combining them with the front drivers in a flexible-beam truck. The first engine on this plan was sent to the Erie and Kalamazoo Railroad, in October, 1843, and gave great satisfaction. The superintendent of the road was enthusiastic in its praise, and wrote to Mr. Baldwin that he doubted "if anything could be got up which would answer the business of the road so well." One was also sent to the Utica and Schenectady Railroad a few weeks later, of which the superintendent remarked that "it worked beautifully, and there were not wagons enough to give it a full load." In this plan the leading wheels were usually made thirty-six and the drivers fifty-four inches in diameter.

This machine, of course, came in competition with the eight-wheeled engine having four drivers, and Mr. Baldwin claimed for his plan a decided superiority. In each case about two-thirds of the total weight was carried on the four drivers, and Mr. Baldwin maintained that his engine, having only six instead of eight wheels, was simpler and more effective.

At about this period Mr. Baldwin's attention was called by Mr. Levi Bissell to an "Air-Spring" which the latter had devised, and which it was imagined was destined to be a cheap, effective, and perpetual spring. The device consisted of a small cylinder placed above the frame over the axle-box, and having a piston fitted air-tight into it. The piston-rod was to bear on the axle-box and the proper quantity of air was to be pumped into the cylinder above the piston, and the cylinder then hermetically closed. The piston had a leather packing which was to be kept moist by some fluid (molasses was proposed) previously introduced into the cylinder. Mr. Baldwin at first proposed to equalize the weight between the two pairs of drivers by connecting two air springs on each side by a pipe, the use of an equalizing beam being covered by Messrs. Eastwick & Harrison's patent. The air-springs were found, however, not to work practically, and were never applied. It may be added that a model of an equalizing air-spring was exhibited by Mr. Joseph Harrison, Jr., at the Franklin Institute, in 1838 or 1839.
With the introduction of the new machine, business began at once to revive, and the tide of prosperity turned once more in Mr. Baldwin's favor. Twelve engines were constructed in 1843, all but four of them of the new pattern; twenty-two engines in 1844, all of the new pattern; and twenty-seven in 1845. Three of this number were of the old type, with one pair of drivers, but from that time forward the old pattern with the single pair of drivers disappeared from the practice of the establishment, save occasionally for exceptional purposes.

In 1842, the partnership with Mr. Vail was dissolved, and Mr. Asa Whitney, who had been superintendent of the Mohawk and Hudson Railroad, became a partner with Mr. Baldwin, and the firm continued as Baldwin & Whitney until 1846, when the latter withdrew to engage in the manufacture of car-wheels, establishing the firm of A. Whitney & Sons, Philadelphia.

Mr. Whitney brought to the firm a railroad experience and thorough business talent. He introduced a system in many details of the management of the business, which Mr. Baldwin, whose mind was devoted more exclusively to mechanical subjects, had failed to establish or wholly ignored. The method at present in use in the establishment, of giving to each class of locomotives a distinctive designation, composed of a number and a letter, originated very shortly after Mr. Whitney's connection with the business. For the purpose of representing the different designs, sheets with engravings of locomotives were employed. The sheet showing the engine with one pair of drivers was marked B; that with two pairs, C; that with three, D; and that with four, E. Taking its rise from this circumstance, it became customary to designate as B engines those with one pair of drivers; as C engines, those with two pairs; as D engines, those with three pairs; and as E engines, those with four pairs. Shortly afterwards, a number, indicating the weight in gross tons, was added. Thus, the 12 D engine was one with three pairs of drivers, and weighing twelve tons; the 12 C, an engine of same weight, but with only four wheels connected. A modification of this method of designating the several plans and sizes is still in use, and is explained elsewhere.

It will be observed that the classification as thus established
began with the B engines. The letter A was reserved for an engine intended to run at very high speeds, and so designed that the driving-wheels should make two revolutions for each reciprocation of the pistons. This was to be accomplished by means of gearing. The general plan of the engine was determined in Mr. Baldwin's mind, but was never carried into execution.

The adoption of the plan of six-wheels-connected engines opened the way at once to increasing their size. The weight being almost evenly distributed on six points, heavier machines were admissible, the weight on any one pair of drivers being little, if any, greater than had been the practice with the old plan of engine having a single pair of drivers. Hence engines of eighteen and twenty tons weight were shortly introduced, and in 1844 three of twenty tons weight, with cylinders sixteen and one-half inches diameter by eighteen inches stroke, were constructed for the Western Railroad of Massachusetts, and six of eighteen tons weight, with cylinders fifteen by eighteen, and drivers forty-six inches in diameter, were built for the Philadelphia and Reading Railroad. It should be noted that three of these latter engines had iron flues. This was the first instance in which Mr. Baldwin had employed tubes of this material, although they had been previously used by others. Lap-welded iron flues were made by Morris, Tasker & Co., of Philadelphia, about 1838, and butt-welded iron tubes had previously been made by the same firm. Ross Winans, of Baltimore, had also made iron tubes by hand for locomotives of his manufacture before 1838. The advantage found to result from the use of iron tubes, apart from their less cost, was that the tubes and boiler-shell, being of the same material, expanded and contracted alike, while in the case of copper tubes the expansion of the metal by heat varied from that of the boiler shell, and as a consequence there was greater liability to leakage at the joints with the tube-sheets. The opinion prevailed largely at that time that some advantage resulted in the evaporation of water, owing to the superiority of copper as a conductor of heat. To determine this question, an experiment was tried with two of the six engines referred to above, one of which, the "Ontario," had copper flues, and another, the "New England," iron flues. In other respects they
were precisely alike. The two engines were run from Richmond to Mount Carbon, August 27, 1844, each drawing a train of one hundred and one empty cars, and, returning, from Mount Carbon to Richmond, on the following day, each with one hundred loaded cars. The quantity of water evaporated and wood consumed was noted, with the result shown in the following table:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;standing at stations&quot;</td>
<td>9h. 7m. 7h. 41m.</td>
<td>5h. 1m. 6h. 8m.</td>
<td>8h. 19m. 9h. 34m.</td>
<td>8h. 19m. 9h. 34m.</td>
</tr>
<tr>
<td>Cords of wood burned</td>
<td>6.68 5.50</td>
<td>6.94 6.94</td>
<td>6.94 6.94</td>
<td>6.94 6.94</td>
</tr>
<tr>
<td>Cubic feet of water evaporated</td>
<td>925.75 757.26</td>
<td>837.46 656.39</td>
<td>837.46 656.39</td>
<td>837.46 656.39</td>
</tr>
<tr>
<td>Ratio, cubic feet of water to a cord of wood</td>
<td>138.57 137.68</td>
<td>120.67 109.39</td>
<td>120.67 109.39</td>
<td>120.67 109.39</td>
</tr>
</tbody>
</table>

The conditions of the experiments not being absolutely the same in each case, the results could not of course be accepted as entirely accurate. They seemed to show, however, no considerable difference in the evaporative efficacy of copper and iron tubes.

The period under consideration was marked also by the introduction of the French & Baird stack, which proved at once to be one of the most successful spark-arresters thus far employed, and which was for years used almost exclusively wherever, as on the cotton-carrying railroads of the South, a thoroughly effective spark-arrester was required. This stack was introduced by Mr. Baird, then a foreman in the works, who purchased the patent-right of what had been known as the Grimes stack, and combined with it some of the features of the stack made by Mr. Richard French, then Master Mechanic of the Germantown Railroad, together with certain improvements of his own. The cone over the straight inside pipe was made with volute flanges on its under side, which gave a rotary motion to the sparks. Around the cone was a casing about six inches smaller in diameter than the outside stack. Apertures were cut in the
sides of this casing, through which the sparks in their rotary motion were discharged, and thus fell to the bottom of the space between the straight inside pipe and the outside stack. The opening in the top of the stack was fitted with a series of \( V \)-shaped iron circles perforated with numerous holes, thus presenting an enlarged area, through which the smoke escaped. The patent right for this stack was subsequently sold to Messrs. Radley & Hunter, and its essential principle is still used in the Radley & Hunter stack as at present made.

In 1845, Mr. Baldwin built three locomotives for the Royal Railroad Company of Würtemberg. They were of fifteen tons weight, on six wheels, four of them being sixty inches in diameter and coupled. The front drivers were combined by the flexible beams into a truck with the smaller leading wheels. The cylinders were inclined and outside, and the connecting-rods took hold of a half-crank axle back of the fire-box. It was specified that these engines should have the link-motion which had shortly before been introduced in England by the Stephensons. Mr. Baldwin accordingly applied a link of a peculiar character to suit his own ideas of the device. The link was made solid, and of a truncated \( V \)-section, and the block was grooved so as to fit and slide on the outside of the link.

During the year 1845 another important feature in locomotive construction—the cut-off valve—was added to Mr. Baldwin's practice. Up to that time the valve-motion had been the two eccentrics, with the single flat hook for each cylinder. Since 1841, Mr. Baldwin had contemplated the addition of some device allowing the steam to be used expansively, and he now added the "half-stroke cut-off." In this device the steam-chest was separated by a horizontal plate into an upper and a lower compartment. In the upper compartment, a valve, worked by a separate eccentric, and having a single opening, admitted steam through a port in this plate to the lower steam-chamber. The valve-rod of the upper valve terminated in a notch or hook, which engaged with the upper arm of its rock-shaft. When thus working, it acted as a cut-off at a fixed part of the stroke, determined by the setting of the eccentric. This was usually at half the stroke. When it was desired to dispense with the cut-
off and work steam for the full stroke, the hook of the valve-rod was lifted from the pin on the upper arm of the rock-shaft by a lever worked from the footboard, and the valve-rod was held in a notched rest fastened to the side of the boiler. This left the opening through the upper valve and the port in the partition plate open for the free passage of steam throughout the whole stroke. The first application of the half-stroke cut-off was made on the engine "Champlain" (20 D), built for the Philadelphia and Reading Railroad Company, in 1845. It at once became the practice to apply the cut-off on all passenger engines, while the six- and eight-wheels-connected freight engines were, with a few exceptions, built for a time longer with the single valve admitting steam for the full stroke.

After building, during the years 1843, 1844, and 1845, ten four-wheels-connected engines on the plan above described, viz., six wheels in all, the leading wheels and the front drivers being combined into a truck by the flexible beams, Mr. Baldwin finally adopted the present design of four drivers and a four-wheeled truck. Some of his customers who were favorable to the latter plan had ordered such machines of other builders, and Colonel Gadsden, President of the South Carolina Railroad Company, called on him in 1845 to build for that line some passenger engines of this pattern. He accordingly bought the patent-right for this plan of engine of Mr. H. R. Campbell, and for the equalizing beams used between the drivers, of Messrs. Eastwick & Harrison, and delivered to the South Carolina Railroad Company, in December, 1845, his first eight-wheeled engine with four drivers and a four-wheeled truck. This machine had cylinders thirteen and three-quarters by eighteen, and drivers sixty inches in diameter, with the springs between them arranged as equalizers. Its weight was fifteen tons. It had the half-crank axle, the cylinders being inside the frame but outside the smoke-box. The inside-connected engine, counterweighting being as yet unknown, was admitted to be steadier in running, and hence more suitable for passenger service. With the completion of the first eight-wheeled "C" engine, Mr. Baldwin's feelings underwent a revulsion in favor of this plan, and his partiality for it became as great as had been his antipathy before. Commenting
on the machine, he recorded himself as "more pleased with its appearance and action than any engine he had turned out." In addition to the three engines of this description for the South Carolina Railroad Company, a duplicate was sent to the Camden and Amboy Railroad Company, and a similar but lighter one to the Wilmington and Baltimore Railroad Company, shortly afterwards. The engine for the Camden and Amboy Railroad Company, and perhaps the others, had the half-stroke cut-off.

From that time forward all of his four-wheels-connected machines were built on this plan, and the six-wheeled "C" engine was abandoned, except in the case of one built for the Philadelphia, Germantown and Norristown Railroad Company, in 1846, and this was afterwards rebuilt into a six-wheels-connected machine. Three methods of carrying out the general design were, however, subsequently followed. At first the half-crank was used; then horizontal cylinders inclosed in the chimney-seat and working a full-crank axle, which form of construction had been practised at the Lowell Works; and eventually, outside cylinders with outside connections.

Meanwhile, the flexible truck machine maintained its popularity for heavy freight service. All the engines thus far built on this plan had been six-wheeled, some with the rear driving-axle back of the fire-box, and others with it in front. The next step, following logically after the adoption of the eight-wheeled "C" engine, was to increase the size of the freight machine, and distribute the weight on eight wheels all connected, the two rear
pairs being rigid in the frame, and the two front pairs combined into the flexible-beam truck. This was first done in 1846, when seventeen engines on this plan were constructed on one order for the Philadelphia and Reading Railroad Company. Fifteen of these were of twenty tons weight, with cylinders fifteen and a half by twenty, and wheels forty-six inches in diameter; and two of twenty-five tons weight, with cylinders seventeen and a quarter by eighteen, and drivers forty-two inches in diameter. These engines were the first ones on which Mr. Baldwin placed sand boxes, and they were also the first built by him with roofs. On all previous engines the footboard had only been inclosed by a railing. On these engines for the Reading Railroad four iron posts were carried up, and a wooden roof supported by them. The engine-men added curtains at the sides and front, and Mr. Baldwin on subsequent engines added sides, with sash and glass. The cab proper, however, was of New England origin, where the severity of the climate demanded it, and where it had been used previous to this period.

Forty-two engines were completed in 1846, and thirty-nine in 1847. The only novelty to be noted among them was the engine "M. G. Bright," built for operating the inclined plane on the Madison and Indianapolis Railroad. The rise of this incline was one in seventeen, from the bank of the Ohio River at Madison. The engine had eight wheels, forty-two inches in diameter, connected, and worked in the usual manner by outside inclined cylinders, fifteen and one-half inches diameter by twenty inches stroke. A second pair of cylinders, seventeen inches in diameter with eighteen inches stroke of piston, was placed vertically over the boiler, midway between the furnace and smoke arch. The connecting-rods worked by these cylinders connected with cranks on a shaft
under the boiler. This shaft carried a single cog-wheel at its centre, and this cog-wheel engaged with another of about twice its diameter on a second shaft adjacent to it and in the same plane. The cog-wheel on this latter shaft worked in a rack-rail placed in the centre of the track. The shaft itself had its bearings in the lower ends of two vertical rods, one on each side of the boiler, and these rods were united over the boiler by a horizontal bar which was connected by means of a bent lever and connecting-rod to the piston worked by a small horizontal cylinder placed on top of the boiler. By means of this cylinder, the yoke carrying the shaft and cog-wheel could be depressed and held down so as to engage the cogs with the rack-rail, or raised out of the way when only the ordinary drivers were required. This device was designed by Mr. Andrew Cathcart, Master Mechanic of the Madison and Indianapolis Railroad. A similar machine, the "John Brough," for the same plane, was built by Mr. Baldwin in 1850. The incline was worked with a rack-rail and these engines until it was finally abandoned and a line with easier gradients substituted.

The use of iron tubes in freight engines grew in favor, and in October, 1847, Mr. Baldwin noted that he was fitting his flues with copper ends, "for riveting to the boiler."

The subject of burning coal continued to engage much attention, but the use of anthracite had not as yet been generally successful. In October, 1847, the Baltimore and Ohio Railroad Company advertised for proposals for four engines to burn Cumberland coal, and the order was taken and filled by Mr. Baldwin with four of his eight-wheels-connected machines. These engines had a heater on top of the boiler for heating the feed-water, and a grate with a rocking-bar in the centre, having fingers on each side which interlocked with projections on fixed bars, one in front and one behind. The rocking-bar was operated from the foot-board. This appears to have been the first instance of the use of a rocking-grate in the practice of these works.

The year 1848 showed a falling off in business, and only twenty engines were turned out. In the following year, however, there was a rapid recovery, and the production of the works
increased to thirty, followed by thirty-seven in 1850, and fifty in 1851. These engines, with a few exceptions, were confined to three patterns, the eight-wheeled four-coupled engine, from twelve to nineteen tons in weight, for passengers and freight, and the six- and eight-wheels-connected engine, for freight exclusively, the six-wheeled machine weighing from twelve to seventeen tons, and the eight-wheeled from eighteen to twenty-seven tons. The drivers of these six- and eight-wheels-connected machines were made generally forty-two, with occasional variations up to forty-eight inches in diameter.

The exceptions referred to in the practice of these years were the fast passenger engines built by Mr. Baldwin during this period. Early in 1848, the Vermont Central Railroad was approaching completion, and Governor Paine, the President of the Company, conceived the idea that the passenger service on the road required locomotives capable of running at very high velocities. Henry R. Campbell, Esq., was a contractor in building the line, and was authorized by Governor Paine to come to Philadelphia and offer Mr. Baldwin ten thousand dollars for a locomotive which could run with a passenger train at a speed of sixty miles per hour. Mr. Baldwin at once undertook to

![Baldwin Fast Passenger Engine, 1848.](image)

meet these conditions. The work was begun early in 1848, and in March of that year Mr. Baldwin filed a caveat for his design. The engine was completed in 1849, and was named the "Governor Paine." It had one pair of driving-wheels, six and a half feet in diameter, placed back of the fire-box. Another pair of
wheels, but smaller and unconnected, was placed directly in front of the fire-box, and a four-wheeled truck carried the front of the engine. The cylinders were seventeen and a quarter inches diameter and twenty inches stroke, and were placed horizontally between the frames and the boiler, at about the middle of the waist. The connecting-rods took hold of “half-cranks” inside of the driving-wheels. The object of placing the cylinders at the middle of the boiler was to lessen or obviate the lateral motion of the engine, produced when the cylinders were attached to the smoke-arch. The bearings on the two rear axles were so contrived that, by means of a lever, a part of the weight of the engine usually carried on the wheels in front of the fire-box could be transferred to the driving-axle. The “Governor Paine” was used for several years on the Vermont Central Railroad, and then rebuilt into a four-coupled machine. During its career, it was stated by the officers of the road that it could be started from a state of rest and run a mile in forty-three seconds. Three engines on the same plan, but with cylinders fourteen by twenty, and six-feet driving-wheels, the “Mifflin,” “Blair,” and “Indiana,” were also built for the Pennsylvania Railroad Company in 1849. They weighed each about forty-seven thousand pounds, distributed as follows: Eighteen thousand on the drivers, fourteen thousand on the pair of wheels in front of the fire-box, and fifteen thousand on the truck. By applying the lever, the weight on the drivers could be increased to about twenty-four thousand pounds, the weight on the wheels in front of the fire-box being correspondingly reduced. A speed of four miles in three minutes is recorded for them, and upon one occasion President Taylor was taken in a special train over the road by one of these machines at a speed of sixty miles an hour. One other engine of this pattern, the “Susquehanna,” was built for the Hudson River Railroad Company in 1850. Its cylinders were fifteen inches diameter by twenty inches stroke, and drivers six feet in diameter. All these engines, however, were short-lived, and died young, of insufficient adhesion.

Eight engines with four drivers connected and half-crank axles were built for the New York and Erie Railroad Company in 1849, with seventeen by twenty-inch cylinders; one-half of the
number with six-feet and the rest with five-feet drivers. These machines were among the last on which the half-crank axle was used. Thereafter, outside-connected engines were constructed almost exclusively.

In May, 1848, Mr. Baldwin filed a caveat for a four-cylinder locomotive, but never carried the design into execution. The first instance of the use of steel axles in the practice of the establishment occurred during the same year,—a set being placed as an experiment under an engine constructed for the Pennsylvania Railroad Company. In 1850, the old form of dome-boiler, which had characterized the Baldwin engine since 1834, was abandoned, and the wagon-top form substituted.

The business in 1851, had reached the full capacity of the shop, and the next year marked the completion of about an equal number of engines (forty-nine). Contracts for work extended a year ahead, and, to meet the demand, the facilities in the various departments were increased, and resulted in the construction of sixty engines in 1853, and sixty-two in 1854.

At the beginning of the latter year, Mr. Matthew Baird, who had been connected with the works since 1836, as one of its foremen, entered into partnership with Mr. Baldwin, and the style of the firm was made M. W. Baldwin & Co.

The only novelty in the general plan of engines during this period was the addition of a ten-wheeled engine to the patterns of the establishment. The success of Mr. Baldwin's engines with all six or eight wheels connected, and the two front pairs combined by the parallel beams into a flexible truck, had been so marked that it was natural that he should oppose any other plan for freight service. The ten-wheeled engine, with six drivers connected, had, however, now become a competitor. This plan of engine was first patented by Septimus Norris, of Philadelphia, in 1846, and the original design was apparently to produce an engine which should have equal tractive power with the Baldwin six-wheels-connected machine. This the Norris patent sought to accomplish by proposing an engine with six drivers connected, and so disposed as to carry substantially the whole weight, the forward drivers being in advance of the centre of gravity of the engine, and the truck only serving as a guide,
the front of the engine being connected with it by a pivot-pin, but without a bearing on the centre-plate. Mr. Norris's first engine on this plan was tried in April, 1847, and was found not to pass curves so readily as was expected. As the truck carried little or no weight, it would not keep the track. The New York and Erie Railroad Company, of which John Brandt was then Master Mechanic, shortly afterwards adopted the ten-wheeled engine, modified in plan so as to carry a part of the weight on the truck. Mr. Baldwin filled an order for this company, in 1850, of four eight-wheels-connected engines, and in making the contract he agreed to substitute a truck for the front pair of wheels if desired after trial. This, however, he was not called upon to do.

In February, 1852, Mr. J. Edgar Thomson, President of the Pennsylvania Railroad Company, invited proposals for a number of freight locomotives of fifty-six thousand pounds weight each. They were to be adapted to burn bituminous coal, and to have six wheels connected and a truck in front, which might be either of two or four wheels. Mr. Baldwin secured the contract, and built twelve engines of the prescribed dimensions, viz., cylinders eighteen by twenty-two; drivers forty-four inches diameter, with chilled tires. Several of these engines were constructed with a single pair of truck-wheels in front of the drivers, but back of the cylinders. It was found, however, after the engines were put in service, that the two truck-wheels carried eighteen thousand or nineteen thousand pounds, and this was objected to by the company as too great a weight to be carried on a single pair of wheels. On the rest of the engines of the order, therefore, a four-wheeled truck in front was employed.

The ten-wheeled engine thereafter assumed a place in the Baldwin classification, but it was some years—not until after 1860, however—before this pattern of engine wholly superseded in Mr. Baldwin's practice the old plan of freight engine on six or eight wheels, all connected.

In 1855-56, two locomotives of twenty-seven tons weight, nineteen by twenty-two cylinders, forty-eight inch drivers, were built for the Portage Railroad, and three for the Pennsylvania Railroad. In 1855, '56, and '57, fourteen of the same dimensions
were built for the Cleveland and Pittsburg Railroad; four for the Pittsburg, Fort Wayne and Chicago Railroad; and one for the Marietta and Cincinnati Railroad. In 1858 and '59, one was constructed for the South Carolina Railroad, of the same size, and six lighter ten-wheelers, with cylinders fifteen and a half by twenty-two, and four-feet drivers, and two with cylinders sixteen by twenty-two, and four-feet drivers, were sent out to railroads in Cuba.

On three locomotives—the "Clinton," "Athens," and "Sparta"—completed for the Central Railroad of Georgia in July, 1852, the driving boxes were made with a slot or cavity in the line of the vertical bearing on the journal. The object was to produce a more uniform distribution of the wear over the entire surface of the bearing. This was the first instance in which this device, which has since come into general use, was employed in the Works, and the boxes were so made by direction of Mr. Charles Whiting, then Master Mechanic of the Central Railroad of Georgia. He subsequently informed Mr. Baldwin that this method of fitting up driving-boxes had been in use on the road for several years previous to his connection with the company. As this device was subsequently made the subject of a patent by Mr. David Matthew, these facts may not be without interest.

In 1853, Mr. Charles Ellet, Chief Engineer of the Virginia Central Railroad, laid a temporary track across the Blue Ridge, at Rock Fish Gap, for use during the construction of a tunnel through the mountain. This track was twelve thousand five hundred feet in length on the eastern slope, ascending in that distance six hundred and ten feet, or at the average rate of one in twenty and a half feet. The maximum grade was calculated for two hundred and ninety-six feet per mile, and prevailed for half a mile. It was found, however, in fact, that the grade in places exceeded three hundred feet per mile. The shortest radius of curvature was two hundred and thirty-eight feet. On the western slope, which was ten thousand six hundred and fifty feet in length, the maximum grade was two hundred and eighty feet per mile, and the ruling radius of curvature three hundred feet. This track was worked by two of the Baldwin six-wheels-connected flexible-beam truck locomotives constructed in 1853-
54. From a description of this track, and the mode of working it, published by Mr. Ellet in 1856, the following is extracted:

"The locomotives mainly relied on for this severe duty were designed and constructed by the firm of M. W. Baldwin & Company, of Philadelphia. The slight modifications introduced at the instance of the writer, to adapt them better to the particular service to be performed in crossing the Blue Ridge, did not touch the working proportions or principle of the engines, the merits of which are due to the patentee, M. W. Baldwin, Esq.

"These engines are mounted on six wheels, all of which are drivers, and coupled, and forty-two inches diameter. The wheels are set very close, so that the distance between the extreme points of contact of the wheels and the rail, of the front and rear drivers, is nine feet four inches. This closeness of the wheels, of course, greatly reduces the difficulty of turning the short curves of the road. The diameter of the cylinders is sixteen and a half inches, and the length of the stroke twenty inches. To increase the adhesion, and at the same time avoid the resistance of a tender, the engine carries its tank upon the boiler, and the footboard is lengthened out and provided with suspended side-boxes, where a supply of fuel may be stored. By this means the weight of wood and water, instead of abstracting from the effective power of the engine, contributes to its adhesion and consequent ability to climb the mountain. The total weight of these engines is fifty-five thousand pounds, or twenty-seven and a half tons, when the boiler and tank are supplied with water, and fuel enough for a trip of eight miles is on board. The capacity of the tank is sufficient to hold one hundred cubic feet of water, and it has storage-room on top for one hundred cubic feet of wood, in addition to what may be carried in the side-boxes and on the footboard.

"To enable the engines better to adapt themselves to the flexures of the road, the front and middle pairs of drivers are held in position by wrought-iron beams, having cylindrical boxes in each end for the journal-bearings, which beams vibrate on spherical pins fixed in the frame of the engine on each side, and resting on the centres of the beams. The object of this arrangement is to form a truck, somewhat flexible, which enables the drivers more readily to traverse the curves of the road.

"The writer has never permitted the power of the engines on this mountain road to be fully tested. The object has been to work the line regularly, economically, and, above all, safely; and these conditions are incompatible with experimental loads subjecting the machinery to severe strains. The regular daily service of each of the engines is to make four trips, of eight miles, over the mountain, drawing one eight-wheel baggage car, together with two eight-wheel passenger cars, in each direction.

"In conveying freight, the regular train on the mountain is three of the eight-wheel house-cars, fully loaded, or four of them when empty or partly loaded.

"These three cars, when full, weigh, with their loads, from forty to forty-three tons. Sometimes, though rarely, when the business has been unusually heavy, the loads have exceeded fifty tons.

"With such trains the engines are stopped on the track, ascending or descending, and are started again, on the steepest grades, at the discretion of the engineer."
"Water, for the supply of the engines, has been found difficult to obtain on the mountain; and, since the road was constructed, a tank has been established on the eastern slope, where the ascending engines stop daily on a grade of two hundred and eighty feet per mile, and are there held by the brakes while the tank is being filled, and started again at the signal and without any difficulty.

"The ordinary speed of the engines, when loaded, is seven and a half miles an hour on the ascending grades, and from five and a half to six miles an hour on the descent.

"When the road was first opened, it speedily appeared that the difference of forty-three feet on the western side, and fifty-eight on the eastern side, between the grades on curves of three hundred feet radii and those on straight lines, was not sufficient to compensate for the increased friction due to such curvature. The velocity, with a constant supply of steam, was promptly retarded on passing from a straight line to a curve, and promptly accelerated again on passing from the curve to the straight line. But, after a little experience in the working of the road, it was found advisable to supply a small amount of grease to the flange of the engine by means of a sponge, saturated with oil, which, when needed, is kept in contact with the wheel by a spring. Since the use of the oil was introduced, the difficulty of turning the curves has been so far diminished, that it is no longer possible to determine whether grades of two hundred and thirty-seven and six-tenths feet per mile on curves of three hundred feet radius, or grades of two hundred and ninety-six feet per mile on straight lines, are traversed most rapidly by the engine.

"When the track is in good condition, the brakes of only two of the cars possess sufficient power to control and regulate the movement of the train,—that is to say, they will hold back the two cars and the engine. When there are three or more cars in the train, the brakes on the cars, of course, command the train so much the more easily.

"But the safety of the train is not dependent on the brakes of the car. There is also a valve or air-cock in the steam-chest, under the control of the engineer. This air-cock forms an independent brake, exclusively at the command of the engineer, and which can always be applied when the engine itself is in working order. The action of this power may be made ever so gradual, either slightly relieving the duty of the brakes on the cars, or bringing into play the entire power of the engine. The train is thus held in complete command."

The Mountain Top Track, it may be added, was worked successfully for several years, by the engines described in the above extract, until it was abandoned on the completion of the tunnel. The exceptionally steep grades and short curves which characterized the line, afforded a complete and satisfactory test of the adaptation of these machines to such peculiar service.

But the period now under consideration was marked by another, and a most important, step in the progress of American locomotive practice. We refer to the introduction of the link motion. Although this device was first employed by William T.
James, of New York, in 1832, and eleven years later by the
Stephensons, in England, and was by them applied thenceforward
on their engines, it was not until 1849 that it was adopted in
this country. In that year Mr. Thomas Rogers, of the Rogers
Locomotive and Machine Company, introduced it in his practice.
Other builders, however, strenuously resisted the innovation, and
none more so than Mr. Baldwin. The theoretical objections
which confessedly apply to the device, but which practically have
been proved to be unimportant, were urged from the first by Mr.
Baldwin as arguments against its use. The strong claim of the
advocates of the link-motion, that it gave a means of cutting off
steam at any point of the stroke, could not be gainsaid, and this
was admitted to be a consideration of the first importance. This
very circumstance undoubtedly turned Mr. Baldwin’s attention
to the subject of methods for cutting off steam, and one of the
first results was his "Variable Cut-off," patented April 27, 1852.
This device consisted of two valves, the upper sliding upon the
lower, and worked by an eccentric and rock-shaft in the usual
manner. The lower valve fitted steam-tight to the sides of the
steam-chest and the under surface of the upper valve. When
the piston reached each end of its stroke, the full pressure of
steam from the boiler was admitted around the upper valve, and
transferred the lower valve instantaneously from one end of the
steam-chest to the other. The openings through the two valves
were so arranged that steam was admitted to the cylinder only
for a part of the stroke. The effect was, therefore, to cut off
steam at a given point, and to open the induction and exhaust
ports substantially at the same instant and to their full extent.
The exhaust port, in addition, remained fully opened while the
induction port was gradually closing, and after it had entirely
closed. Although this device was never put in use, it may be
noted in passing that it contained substantially the principle of
the steam-pump, as since patented and constructed.

Early in 1853, Mr. Baldwin abandoned the half-stroke cut-off,
previously described, and which he had been using since 1845,
and adopted the variable cut-off, which was already employed by
other builders. One of his letters, written in January, 1853, states
his position, as follows:
"I shall put on an improvement in the shape of a variable cut-off, which can be operated by the engineer while the machine is running, and which will cut off anywhere from six to twelve inches, according to the load and amount of steam wanted, and this without the link-motion, which I could never be entirely satisfied with. I still have the independent cut-off, and the additional machinery to make it variable will be simple and not liable to be deranged."

This form of cut-off was a separate valve, sliding on a partition plate between it and the main steam-valve, and worked by an independent eccentric and rock-shaft. The upper arm of the rock-shaft was curved so as to form a radius-arm, on which a sliding-block, forming the termination of the upper valve-rod, could be adjusted and held at varying distances from the axis, thus producing a variable travel of the upper valve. This device did not give an absolutely perfect cut-off, as it was not operative in backward gear, but when running forward it would cut off with great accuracy at any point of the stroke, was quick in its movement, and economical in the consumption of fuel.

After a short experience with this arrangement of the cut-off, the partition plate was omitted, and the upper valve was made to slide directly on the lower. This was eventually found objectionable, however, as the lower valve would soon cut a hollow in the valve-face. Several unsuccessful attempts were made to remedy this defect by making the lower valve of brass, with long bearings, and making the valve-face of the cylinder of hardened steel; finally, however, the plan of one valve on the other was aban-

---

**Variable Cut-off Adjustment.**

doned, and a recourse was again had to an interposed partition plate, as in the original half-stroke cut-off.

Mr. Baldwin did not adopt this form of cut-off without some modification of his own, and the modification in this instance consisted of a peculiar device, patented September 13, 1835, for rais-
ing and lowering the block on the radius-arm. A quadrant was placed so that its circumference bore nearly against a curved arm projecting down from the sliding-block, and which curved in the reverse direction from the quadrant. Two steel straps side by side were interposed between the quadrant and this curved arm. One of the straps was connected to the lower end of the quadrant and the upper end of the curved arm; the other, to the upper end of the quadrant and the lower end of the curved arm. The effect was the same as if the quadrant and arm geared into each other in any position by teeth, and theoretically the block was kept steady in whatever position placed on the radius-arm of the rock-shaft. This was the object sought to be accomplished, and was stated in the specification of the patent as follows:

"The principle of varying the cut-off by means of a vibrating arm and sliding pivot-block has long been known, but the contrivances for changing the position of the block upon the arm have been very defective. The radius of motion of the link by which the sliding-block is changed on the arm, and the radius of motion of that part of the vibrating arm on which the block is placed, have, in this kind of valve gear, as heretofore constructed, been different, which produced a continual rubbing of the sliding-block upon the arm while the arm is vibrating; and as the block for the greater part of the time occupies one position on the arm, and only has to be moved towards either extremity occasionally, that part of the arm on which the block is most used soon becomes so worn that the block is loose, and jars."

This method of varying the cut-off was first applied on the engine "Belle," delivered to the Pennsylvania Railroad Company, December 6, 1854, and thereafter was for some time employed by Mr. Baldwin. It was found, however, in practice that the steel straps would stretch sufficiently to allow them to buckle and break, and hence they were soon abandoned, and chains substituted between the quadrant and curved arm of the sliding-block. These chains in turn proved little better, as they lengthened, allowing lost motion, or broke altogether, so that eventually the quadrant was wholly abandoned, and recourse was finally had to the lever and link for raising and lowering the sliding-block. As thus arranged, the cut-off was substantially what was known as the "Cuyahoga Cut-off," as introduced by Mr. Ethan Rogers, of the Cuyahoga Works, Cleveland, Ohio, except that Mr. Baldwin used a partition plate between the upper and the lower valve.
But while Mr. Baldwin, in common with many other builders, was thus resolutely opposing the link-motion, it was nevertheless rapidly gaining favor with Railroad managers. Engineers and master mechanics were everywhere learning to admire its simplicity, and were manifesting an enthusiastic preference for engines so constructed. At length, therefore, he was forced to succumb; and the link was applied to the "Pennsylvania," one of two engines completed for the Central Railroad of Georgia, in February, 1854. The other engine of the order, the "New Hampshire," had the variable cut-off, and Mr. Baldwin, while yielding to the demand in the former engine, was undoubtedly sanguine that the working of the latter would demonstrate the inferiority of the new device. In this, however, he was disappointed, for in the following year the same company ordered three more engines, on which they specified the link-motion. In 1856 seventeen engines for nine different companies had this form of valve-gear, and its use was thus incorporated in his practice. It was not, however, until 1857 that he was induced to adopt it exclusively.

February 14, 1854, Mr. Baldwin and Mr. David Clark, Master Mechanic of the Mine Hill Railroad, took out conjointly a patent for a feed-water heater, placed at the base of a locomotive chimney, and consisting of one large vertical flue, surrounded by a number of smaller ones. The exhaust steam was discharged from the nozzles through the large central flue, creating a draft of the products of combustion through the smaller surrounding flues. The pumps forced the feed-water into the chamber around these flues, whence it passed to a boiler by the pipe from the back of the stack. This heater was applied on several engines for the Mine Hill Railroad, and on a few other roads; but its use was exceptional, and lasted only for a year or two.

In December of the same year, Mr. Baldwin filed a caveat for a variable exhaust, operated automatically, by the pressure of steam, so as to close when the pressure was lowest in the boiler, and open with the increase of pressure. The device was never put in service.

The use of coal, both bituminous and anthracite, as a fuel for locomotives, had by this time become a practical success. The
economical combustion of bituminous coal, however, engaged considerable attention. It was felt that much remained to be accomplished in consuming the smoke and deriving the maximum of useful effect from the fuel. Mr. Baird, who was now associated with Mr. Baldwin in the management of the business, made this matter a subject of careful study and investigation. An experiment was conducted under his direction, by placing a sheet-iron deflector in the fire-box of an engine on the Germantown and Norristown Railroad. The success of the trial was such as to show conclusively that a more complete combustion resulted. As, however, a deflector formed by a single plate of iron would soon be destroyed by the action of the fire, Mr. Baird proposed to use a water-leg projecting upward and backward from the front of the fire-box under the flues. Drawings and a model of the device were prepared, with a view of patenting it, but subsequently the intention was abandoned, Mr. Baird concluding that a fire-brick arch as a deflector to accomplish the same object was preferable. This was accordingly tried on two locomotives built for the Pennsylvania Railroad Company in 1854, and was found so valuable an appliance that its use was at once established, and it was put on a number of engines built for railroads in Cuba and elsewhere. For several years the fire-bricks were supported on side plugs; but in 1858, in the “Media,” built for the West Chester and Philadelphia Railroad Company, water-pipes extending from the crown obliquely downward and curving to the sides of the fire-box at the bottom were successfully used for the purpose.

The adoption of the link-motion may be regarded as the dividing line between the present and the early and transitional stage of locomotive practice. Changes since that event have been principally in matters of detail, but it is the gradual perfection of these details which has made the locomotive the symmetrical, efficient, and wonderfully complete piece of mechanism it is today. In perfecting these minutiae, the Baldwin Locomotive Works has borne its part, and it only remains to state briefly its contributions in this direction.

The production of the establishment during the six years from 1855 to 1860, inclusive, was as follows: forty-seven engines in
1855; fifty-nine in 1856; sixty-six in 1857; thirty-three in 1858; seventy in 1859; and eighty-three in 1860. The greater number of these were of the ordinary type, four drivers coupled, and a four-wheeled truck, and varying in weight from fifteen ton engines, with cylinders twelve by twenty-two, to twenty-seven ton engines, with cylinders sixteen by twenty-four. A few ten-wheeled engines were built, as has been previously noted, and the remainder were the Baldwin flexible-truck six- and eight-wheels-connected engines. The demand for these, however, was now rapidly falling off, the ten-wheeled and heavy "C" engines taking their place, and by 1859 they ceased to be built, save in exceptional cases, as for some foreign roads, from which orders for this pattern were still occasionally received.

A few novelties characterizing the engines of this period may be mentioned. Several engines built in 1855 had cross-flues placed in the fire-box, under the crown, in order to increase the heating surface. This feature, however, was found impracticable, and was soon abandoned. The intense heat to which the flues were exposed converted the water contained in them into highly superheated steam, which would force its way out through the water around the fire-box with violent ebullitions. Four engines were built for the Pennsylvania Railroad Company, in 1856-57, with straight boilers and two domes. The "Delano" grate, by means of which the coal was forced into the fire-box from below, was applied on four ten-wheeled engines for the Cleveland and Pittsburg Railroad in 1857. In 1859 several engines were built with the form of boiler introduced on the Cumberland Valley Railroad in 1851 by Mr. A. F. Smith, and which consisted of a combustion-chamber in the waist of the boiler, next the fire-box. This form of boiler was for some years thereafter largely used in engines for soft coal. It was at first constructed with the "water-leg," which was a vertical water-space, connecting the top and bottom sheets of the combustion-chamber, but eventually this feature was omitted, and an unobstructed combustion-chamber employed. Several engines were built for the Philadelphia, Wilmington and Baltimore Railroad Company in 1859, and thereafter, with the "Dimpfel" boiler, in which the tubes contain water, and, starting downward from the crown-sheet, are curved to the hori-
zontal, and terminate in a narrow water-space next the smoke-box. The whole waist of the boiler, therefore, forms a combustion-chamber, and the heat and gases, after passing for their whole length along and around the tubes, emerge into the lower part of the smoke-box.

In 1860 an engine was built for the Mine Hill Railroad, with a boiler of a peculiar form. The top sheets sloped upward from both ends towards the centre, thus making a raised part or hump in the centre. The engine was designed to work on heavy grades, and the object sought by Mr. Wilder, the Superintendent of the Mine Hill Railroad, was to have the water always at the same height in the space from which steam was drawn, whether going up or down grade.

All these experiments are indicative of the interest then prevailing upon the subject of coal-burning. The result of experience and study had meantime satisfied Mr. Baldwin that to burn soft coal successfully required no peculiar devices; that the ordinary form of boiler, with plain fire-box, was right, with perhaps the addition of a fire-brick deflector; and that the secret of the economical and successful use of coal was in the mode of firing, rather than in a different form of furnace.

The year 1861 witnessed a marked falling off in the production. The breaking out of the Civil War at first unsettled business, and by many it was thought that railroad traffic would be so largely reduced that the demand for locomotives must cease altogether. A large number of hands were discharged from the Works, and only forty locomotives were turned out during the year. It was even seriously contemplated to turn the resources of the establishment to the manufacture of shot and shell, and other munitions of war, the belief being entertained that the building of locomotive would have to be altogether suspended. So far, however, was this from being the case, that, after the first excitement had subsided, it was found that the demand for transportation by the general government, and by the branches of trade and production stimulated by the war, was likely to tax the carrying capacity of the principal Northern railroads to the fullest extent. The government itself became a large purchaser of locomotives, and it is noticeable, as indicating the increase of travel and freight
transportation, that heavier machines than had ever before been built became the rule. Seventy-five engines were sent from the works in 1862; ninety-six in 1863; one hundred and thirty in 1864; and one hundred and fifteen in 1865. During two years of this period, from May, 1862, to June, 1864, thirty-three engines were built for the United States Military Railroads. The demand from the various coal-carrying roads in Pennsylvania and vicinity was particularly active, and large numbers of ten-wheeled engines, and of the heaviest eight-wheeled four-coupled engines, were built. Of the latter class, the majority were fifteen- and sixteen-inch cylinders, and of the former, seventeen- and eighteen-inch cylinders.

The introduction of several important features in construction marks this period. Early in 1861, four eighteen-inch cylinder freight locomotives, with six coupled wheels, fifty-two inches in diameter, and a Bissell pony-truck with radius-bar in front, were sent to the Louisville and Nashville Railroad Company. This was the first instance of the use of the Bissell truck in the Baldwin Works. These engines, however, were not of the regular "Mogul" type, as they were only modifications of the ten-wheeler, the drivers retaining the same position well back, and a pair of pony-wheels on the Bissell plan taking the place of the ordinary four-wheeled truck. Other engines of the same pattern, but with eighteen and one-half inch cylinders, were built in 1862-63, for the same company, and for the Dom Pedro II. Railway of Brazil.

The introduction of steel in locomotive-construction was a distinguishing feature of the period. Steel tires were first used in the works in 1862, on some engines for the Dom Pedro II. Railway of South America. Their general adoption on American Railroads followed slowly. No tires of this material were then made in this country, and it was objected to their use that, as it took from sixty to ninety days to import them, an engine, in case of a breakage of one of its tires, might be laid up useless for several months. To obviate this objection M. W. Baldwin & Co. imported five hundred steel tires, most of which were kept in stock, from which to fill orders. The steel tires as first used in 1862 on the locomotives for the Dom Pedro Segundo Railway
were made with a "shoulder" at one edge of the internal periphery, and were shrunk on the wheel-centres. The sketch below shows a section of the tire as then used.

Steel fire-boxes were first built for some engines for the Pennsylvania Railroad Company in 1861. English steel of a high temper was used, and at the first attempt the fire-boxes cracked in fitting them in the boilers, and it became necessary to take them out and substitute copper. American homogeneous cast-steel was then tried on engines 231 and 232, completed for the Pennsylvania Railroad in January, 1862, and it was found to work successfully. The fire-boxes of nearly all engines thereafter built for that road were of this material, and in 1866 its use for the purpose became general. It may be added that while all steel sheets for fire-boxes or boilers are required to be thoroughly annealed before delivery, those which are flanged or worked in the process of boiler construction are a second time annealed before riveting.

Another feature of construction gradually adopted was the placing of the cylinders horizontally. This was first done in the case of an outside-connected engine, the "Ocmulgee," which was sent to the Southwestern Railroad Company of Georgia, in January, 1858. This engine had a square smoke-box, and the cylinders were bolted horizontally to its sides. The plan of casting the cylinder and half-saddle in one piece and fitting it to the round smoke-box was introduced by Mr. Baldwin, and grew naturally out of his original method of construction. Mr. Baldwin was the first American builder to use an outside cylinder, and he made it for his early engines with a circular flange cast to it, by which it could be bolted to the boiler. The cylinders were gradually brought lower, and at a less angle, and the flanges prolonged and enlarged. In 1852, three six-wheels-
connected engines, for the Mine Hill Railroad Company, were built with the cylinder flanges brought around under the smoke-box until they nearly met, the space between them being filled with a spark-box. This was practically equivalent to making the cylinder and half-saddle in one casting. Subsequently, on other engines on which the spark-box was not used, the half-saddles were cast so as almost to meet under the smoke-box, and, after the cylinders were adjusted in position, wedges were fitted in the interstices and the saddles bolted together. It was finally discovered that the faces of the two half-saddles might be planed and finished so that they could be bolted together and bring the cylinders accurately in position, thus avoiding the troublesome and tedious job of adjusting them by chipping and fitting to the boiler and frames. With this method of construction, the cylinders were placed at a less and less angle, until at length the truck-wheels were spread sufficiently, on all new or modified classes of locomotives in the Baldwin list, to admit of the cylinders being hung horizontally, as is the present almost universal American practice. By the year 1865 horizontal cylinders were made in all cases where the patterns would allow it. The advantages of this arrangement are manifestly in the interest of simplicity and economy, as the cylinders are thus rights or lefts, indiscriminately, and a single pattern answers for either side.

A distinguishing feature in the method of construction which characterizes these works is the extensive use of a system of standard gauges and templates, to which all work admitting of this process is required to be made. The importance of this arrangement, in securing absolute uniformity of essential parts in all engines of the same class, is manifest, and with the increased production since 1861 it became a necessity as well as a decided advantage. It has already been noted that as early as 1839, Mr. Baldwin felt the importance of making all like parts of similar engines absolutely uniform and interchangeable. It was not attempted to accomplish this object, however, by means of a complete system of standard gauges, until many years later. In 1861 a beginning was made of organizing all the departments of manufacture upon this basis, and from it has since grown an
elaborate and perfected system, embracing all the essential details of construction. An independent department of the works, having a separate foreman and an adequate force of skilled workmen with special tools adapted to the purpose, is organized as the Department of Standard Gauges. A system of standard gauges and templates for every description of work to be done is made and kept by this department. The original templates are kept as "standards," and are never used on the work itself, but from them exact duplicates are made, which are issued to the foremen of the various departments, and to which all work is required to conform. The working gauges are compared with the standards at regular intervals, and absolute uniformity is thus maintained. The system is carried into every possible important detail. Frames are planed and slotted to gauges, and drilled to steel bushed templates. Cylinders are bored and planed, and steam-ports, with valves and steam-chests, finished and fitted, to gauges. Tires are bored, centres turned, axles finished, and cross-heads, guides, guide-bearers, pistons, connecting- and parallel-rods planed, slotted, or finished by the same method. Every bolt about the engine is made to a gauge, and every hole drilled and reamed to a templet. The result of the system is an absolute uniformity and interchangeableness of parts in engines of the same class, insuring to the purchaser the minimum cost of repairs, and rendering possible, by the application of this method, the large production which these works have accomplished.

Thus had been developed and perfected the various essential details of existing locomotive practice when Mr. Baldwin died, September 7, 1866. He had been permitted, in a life of unusual activity and energy, to witness the rise and wonderful increase of a material interest which had become the distinguishing feature of the century. He had done much, by his own mechanical skill and inventive genius, to contribute to the development of that interest. His name was as "familiar as household words" wherever on the American continent the locomotive had penetrated. An ordinary ambition might well have been satisfied with this achievement. But Mr. Baldwin's claim to the remembrance of his fellow-men rests not alone on the results of his
mechanical labors. A merely technical history, such as this, is not the place to do justice to his memory as a man, as a Christian, and as a philanthropist; yet the record would be manifestly imperfect, and would fail properly to reflect the sentiments of his business associates who so long knew him in all relations of life, were no reference made to his many virtues and noble traits of character. Mr. Baldwin was a man of sterling integrity and singular conscientiousness. To do right, absolutely and unreservedly, in all his relations with men, was an instinctive rule of his nature. His heroic struggle to meet every dollar of his liabilities, principal and interest, after his failure, consequent upon the general financial crash in 1837, constitutes a chapter of personal self-denial and determined effort which is seldom paralleled in the annals of commercial experience. When most men would have felt that an equitable compromise with creditors was all that could be demanded in view of the general financial embarrassment, Mr. Baldwin insisted upon paying all claims in full, and succeeded in doing so only after nearly five years of unremitting industry, close economy, and absolute personal sacrifices. As a philanthropist and a sincere and earnest Christian, zealous in every good work, his memory is cherished by many to whom his contributions to locomotive improvement are comparatively unknown. From the earliest years of his business life the practice of systematic benevolence was made a duty and a pleasure. His liberality constantly increased with his means. Indeed, he would unhesitatingly give his notes, in large sums, for charitable purposes when money was absolutely wanted to carry on his business. Apart from the thousands which he expended in private charities, and of which, of course, little can be known, Philadelphia contains many monuments of his munificence. Early taking a deep interest in all Christian effort, his contributions to missionary enterprise and church extension were on the grandest scale, and grew with increasing wealth. Numerous church edifices in this city, of the denomination to which he belonged, owe their existence largely to his liberality, and two at least were projected and built by him entirely at his own cost. In his mental character, Mr. Baldwin was a man of remarkable firmness of purpose. This trait was strongly shown during his
mechanical career in the persistency with which he would work at a new improvement or resist an innovation. If he was led sometimes to assume an attitude of antagonism to features of locomotive-construction which after-experience showed to be valuable,—and a desire for historical accuracy has required the mention, in previous pages, of several instances of this kind,—it is at least certain that his opposition was based upon a conscientious belief in the mechanical impolicy of the proposed changes.

After the death of Mr. Baldwin the business was reorganized in 1867, under the title of "The Baldwin Locomotive Works." M. Baird & Co., Proprietors. Messrs. George Burnham and Charles T. Parry, who had been connected with the establishment from an early period, the former in charge of the finances, and the latter as General Superintendent, were associated with Mr. Baird in the copartnership. Three years later, Messrs. Edward H. Williams, Wiliam P. Henszey, and Edward Longstreth became members of the firm. Mr. Williams had been connected with railway management on various lines since 1850. Mr. Henszey had been Mechanical Engineer, and Mr. Longstreth the General Superintendent of the works for several years previously.

The production of the Baldwin Locomotive Works from 1866 to 1871, both years inclusive, was as follows:

1866, one hundred and eighteen locomotives.
1867, one hundred and twenty-seven "
1868, one hundred and twenty-four "
1869, two hundred and thirty-five "
1870, two hundred and eighty "
1871, three hundred and thirty-one "

In July, 1866, the engine "Consolidation" was built for the Lehigh Valley Railroad, on the plan and specification furnished by Mr. Alexander Mitchell, Master Mechanic of the Mahanoy Division of that Railroad. This engine was intended for working the Mahanoy plane, which rises at the rate of one hundred and thirty-three feet per mile. The "Consolidation" had cylinders twenty by twenty-four, four pairs of drivers connected, forty-eight
inches in diameter, and a Bissell pony-truck in front, equalized with the front drivers. The weight of the engine, in working order, was ninety thousand pounds, of which all but about ten thousand pounds was on the drivers. This engine has constituted the first of a class to which it has given its name, and "Consolidation" engines have since been constructed for a large number of railways, not only in the United States, but in Mexico, Brazil, and Australia. Later engines of the class for the four feet eight and a half inch gauge have, however, been made heavier.

A class of engines known as "Moguls," with three pairs of drivers connected and a swinging pony-truck in front equalized with the forward drivers, took its rise in the practice of this establishment from the "E. A. Douglas," built for the Thomas Iron Company in 1867. These engines are fully illustrated in the catalogue. Several sizes of "Moguls" have been built, but principally with cylinders sixteen to nineteen inches in diameter, and twenty-two or twenty-four inches stroke, and with drivers from forty-four to fifty-seven inches in diameter. This plan of engine has rapidly grown in favor for freight service on heavy grades or where maximum loads are to be moved, and has been adopted by several leading lines. Utilizing, as it does, nearly the entire weight of the engine for adhesion, the main and back pairs of drivers being equalized together, as also the front drivers and the pony-wheels, and the construction of the engine with swing-truck and one pair of drivers without flanges allowing it to pass short curves without difficulty, the "Mogul" is generally accepted as a type of engine especially adapted to the economical working of heavy freight traffic.
In 1867, on a number of eight-wheeled four-coupled engines for the Pennsylvania Railroad, the four-wheeled swing-bolster-truck was first applied, and thereafter a large number of engines have been so constructed. The two-wheeled or "pony-truck" has been built both on the Bissell plan, with double inclined slides, and with the ordinary swing-bolster, and in both cases with the radius-bar pivoting from a point about four feet back from the centre of the truck. The four-wheeled truck has been made with swinging or sliding bolster, and both with and without the radius-bar. Of the engines above referred to as the first on which the swing-bolster-truck was applied, four were for express passenger service, with drivers sixty-seven inches in diameter, and cylinders seventeen by twenty-four. One of them, placed on the road September 9, 1867, was in constant service until May 14, 1871, without ever being off its wheels for repairs, making a total mileage of one hundred and fifty-three thousand two hundred and eighty miles. All of these engines have their driving-wheels spread eight and one-half feet between centres.

Steel flues were first used in three ten-wheeled freight engines, Numbers 211, 338, and 368, completed for the Pennsylvania Railroad in August, 1868. Steel boilers were first made in 1868 for locomotives for the Pennsylvania Railroad Company, and the use of this material for the barrels of boilers as well as for the fire-boxes has now become universal in American practice.

In 1854, four engines for the Pennsylvania Railroad Company, the "Tiger," "Leopard," "Hornet," and "Wasp," were built with straight boilers and two domes each, and in 1866 this method of construction was revived, and until about 1880 the practice of the establishment included both the wagon-top boiler with single dome, and the straight boiler with one or two domes. When the straight boiler is used the waist is made about two inches larger in diameter than that of the wagon-top form. About equal space for water and steam is thus given in either case, and, as the number of flues is the same in both forms, more room for the circulation of water between the flues is afforded in the straight boiler on account of its larger diameter, than in the wagon-top shape. Since 1880 the use of two domes has been
exceptional, both wagon-top and straight boilers being constructed with one dome.

In 1868, a locomotive of three and a half feet gauge was constructed for the Averill Coal and Oil Company, of West Virginia. This was the first narrow-gauge locomotive in the practice of the Works.

In 1869 three locomotives of the same gauge were constructed for the União Valenciana Railway of Brazil, and were the first narrow-gauge locomotives constructed at these Works for general passenger and freight traffic. In the following year the Denver and Rio Grande Railway, of Colorado, was projected on the three-feet gauge, and the first locomotives for the line were designed and built in 1871. Two classes, for passenger and freight respectively, were constructed. The former were six-wheeled, four wheels coupled forty inches in diameter, nine by sixteen cylinders, and weighed each, loaded, about twenty-five thousand pounds. The latter were eight-wheeled, six-wheels coupled thirty-six inches in diameter, eleven by sixteen cylinders, and weighed each, loaded, about thirty-five thousand pounds. Each had a swinging-truck of a single pair of wheels in front of the cylinders. The latter type has been maintained for freight service up to the present time, but principally of larger sizes, engines as heavy as fifty thousand pounds having been turned out. The former type for passenger service was found to be too small and to be unsteady on the track, owing to its comparatively short wheel-base. It was therefore abandoned, and the ordinary "American" pattern, eight-wheeled, four-coupled, substituted. Following the engines for the Denver and Rio Grande Railway, others for other narrow-gauged lines were called for, and the manufacture of this description of rolling stock soon assumed importance.

The "Consolidation" type, as first introduced for the four feet eight and one-half inches gauge in 1866, was adapted to the three-feet gauge in 1873. In 1877 a locomotive on this plan, weighing in working order about sixty thousand pounds, with cylinders fifteen by twenty, was built for working the Garland extension of the Denver and Rio Grande Railway, which crosses the Rocky Mountains with maximum grades of two hundred
and eleven feet per mile, and minimum curves of thirty degrees. The performance of this locomotive, the "Alamosa," is given in the following extract from a letter from the then General Superintendent of that railway:

"Denver, Col., Aug. 31, 1877.

"On the 29th inst. I telegraphed you from Veta Pass—Sangre de Cristo Mountains—that engine 'Alamosa' had just hauled from Garland to the Summit one baggage car and seven coaches, containing one hundred and sixty passengers. Yesterday I received your reply asking for particulars, etc.

"My estimate of the weight was eighty-five net tons, stretched over a distance of three hundred and sixty feet, or including the engine, of four hundred and five feet.

"The occasion of this sized train was an excursion from Denver to Garland and return. The night before, in going over from La Veta, we had over two hundred passengers, but it was 8 p.m., and, fearing a slippery rail, I put on engine No. 19 as a pusher, although the engineer of the 'Alamosa' said he could haul the train, and I believe he could have done so. The engine and train took up a few feet more than the half circle at 'Mule Shore,' where the radius is one hundred and ninety-three feet. The engine worked splendidly, and moved up the two hundred and eleven feet grades and around the thirty degree curves seemingly with as much ease as our passenger engines on 75 feet grades with three coaches and baggage cars.

"The 'Alamosa' hauls regularly eight loaded cars and caboose, about one hundred net tons; length of train about two hundred and thirty feet.

"The distance from Garland to Veta Pass is fourteen and one quarter miles, and the time is one hour and twenty minutes.

"Respectfully yours,

(Signed) W. W. BORST, Sup't."

In addition to narrow-gauge locomotives for the United States, this branch of the product has included a large number of one-metre gauge locomotives for Brazil, three-feet gauge locomotives for Cuba, Mexico, and Peru, and three and one-half feet gauge stock for Costa Rica, Nicaragua, Canada, and Australia.

Locomotives for single-rail railroads were built in 1878 and early in 1879, adapted respectively to the systems of General Roy Stone and Mr. W. W. Riley.

Mine locomotives, generally of narrow-gauge, for underground work, and not over five and one-half feet in height, were first built in 1870. These machines have generally been four-wheels connected, with inside cylinders and a crank-axle. The width over all of this plan is only sixteen inches greater than the gauge of the track. A number of outside-connected mine locomotives have, however, also been constructed. In this
NARROW-GAUGE LOCOMOTIVES.

pattern the width is thirty-two inches greater than the gauge of
the track. A locomotive of twenty inches gauge for a gold mine
in California was built in 1876, and was found entirely practicable
and efficient.

In 1870, in some locomotives for the Kansas Pacific Railway,
the steel tires were shrunk on without being secured by bolts or
rivets in any form, and since that time this method of putting on
tires has been the rule.

In 1871 forty locomotives were constructed for the Ohio and
Mississippi Railway, the gauge of which was changed from five
feet six inches to four feet eight and one-half inches. The entire
lot of forty locomotives was completed and delivered in about
twelve weeks. The gauge of the road was changed on July 4,
and the forty locomotives went at once into service in operating
the line on the standard gauge.

During the same year two “double-end” engines of Class
10-26 1/4 C were constructed for the Central Railroad of New
Jersey, and were the first of this pattern at these Works.

The product of the Works, which had been steadily increasing
for some years in sympathy with the requirements of the numer-
ous new railroads which were constructing, reached three hundred
and thirty-one locomotives in 1871, and four hundred and twenty-
two in 1872. Orders for ninety locomotives for the Northern
Pacific Railroad were entered during 1870-71, and for one hun-
dred and twenty-four for the Pennsylvania Railroad during 1872-
73, and mostly executed during those years. A contract was
also made during 1872 with the Veronej-Rostoff Railway of Rus-

sia for ten locomotives to burn Russian anthracite coal. Six
were “Moguls,” with cylinders nineteen by twenty-four, and
driving-wheels four and one-half feet diameter; and four were
passenger locomotives, “American” pattern, with cylinders
seventeen by twenty-four, and driving-wheels five and one-half
feet diameter. Nine “American” pattern locomotives, fifteen by
twenty-four cylinders, and five feet driving-wheels, were also
constructed in 1872-73 for the Hango-Hyvinge Railway of
Finland.

Early in 1873, Mr. Baird retired from the business, having sold
his interest in the Works to his five partners. Mr. Baird died
May 19, 1877. A new firm was formed under the style of Burn-
ham, Parry, Williams & Co., dating from January 1, 1873, and
Mr. John H. Converse, who had been connected with the
Works since 1870, became a partner. The product of this year
was four hundred and thirty-seven locomotives, the greatest in
the history of the business. During a part of the year ten locomo-
tives per week were turned out. Nearly three thousand men
were employed. Forty-five locomotives for the Grand Trunk
Railway of Canada were built in August, September, and Octo-
ber, 1873, and all were delivered in five weeks after ship-
ment of the first. As in the case of the Ohio and Mississippi
Railway, previously noted, these were to meet the requirements
of a change of gauge from five and one-half feet to four feet
eight and one-half inches. In November, 1873, under circum-
stances of especial urgency, a small locomotive for the Meier
Iron Company of St. Louis was wholly made from the raw ma-
terial in sixteen working days.

The financial difficulties which prevailed throughout the
United States, beginning in September, 1873, and affecting chiefly
the railroad interests and all branches of manufacture connected
therewith, have operated of course to curtail the production of
locomotives since that period. Hence, only two hundred and
five locomotives were built in 1874, and one hundred and thirty
in 1875. Among these may be enumerated two sample locomo-
tives for burning anthracite coal (one passenger, sixteen by
twenty-four cylinders, and one "Mogul" freight, eighteen by
twenty-four cylinders) for the Technical Department of the
Russian Government; also, twelve "Mogul" freight locomotives,
nineteen by twenty-four cylinders, for the Charkoff Nicolaieff
Railroad of Russia. A small locomotive to work by compressed
air, for drawing street-cars, was constructed during 1874 for the
Compressed Air Locomotive and Street-Car Company of Louis-
ville, Ky. It had cylinders seven by twelve, and four wheels
coupled, thirty inches in diameter. Another and smaller locomo-
tive to work by compressed air was constructed three years later
for the Plymouth Cordage Company of Massachusetts, for
service on a track in and about their works. It had cylinders
five by ten, four wheels coupled twenty-four inches diameter,
weight seven thousand pounds, and has been successfully employed for the work required.

The year 1876, noted as the year of the Centennial International Exhibition in Philadelphia, brought some increase of business, and two hundred and thirty-two locomotives were constructed. An exhibit consisting of eight locomotives was prepared for this occasion. With the view of illustrating not only the different types of American locomotives, but the practice of different railroads, the exhibit consisted chiefly of locomotives constructed to fill orders from various railroad companies of the United States, and from the Imperial Government of Brazil. A "Consolidation" locomotive for burning anthracite coal, for the Lehigh Valley Railroad, for which line the first locomotive of this type was designed and built in 1866; a similar locomotive, to burn bituminous coal, and a passenger locomotive for the same fuel for the Pennsylvania Railroad; a "Mogul" freight locomotive, the "Principe do Grão Pará," for the Dom Pedro Segundo Railway of Brazil; and a passenger locomotive (anthracite burner) for the Central Railroad of New Jersey, comprised the larger locomotives contributed by these Works to the Exhibition of 1876. To these were added a mine locomotive and two narrow (three feet) gauge locomotives which were among those used in working the Centennial Narrow-Gauge Railway. As this line was in many respects unique, we subjoin the following extracts from an account by its General Manager of the performance of the two three-feet gauge locomotives:

"The gauge of the line was three feet, with double track three and a half miles long, or seven miles in all. For its length it was probably the most crooked road in the world, being made up almost wholly of curves, in order to run near all the principal buildings on the Exhibition grounds. Many of these curves were on our heaviest grades, some having a radius of 215, 230 and 250 feet on grades of 140 and 155 feet per mile. These are unusually heavy grades and curves, and when combined as we had them, with only a thirty-five pound iron rail, made the task for our engines exceedingly difficult.

"Your locomotive 'Schuylkill,' Class 8-18 C (eight-wheeled, four wheels coupled three and a half feet diameter, cylinders twelve by sixteen, weight forty-two thousand six hundred and fifty pounds), began service May 13, and made one hundred and fifty-six days to the close of the Exhibition. The locomotive 'Delaware,' Class 8-18 D (eight-wheeled, six wheels coupled three feet diameter, cylinders twelve by sixteen, weight thirty-nine thousand pounds), came into service June 9,
and made one hundred and thirty-one days to the close of the Exhibition. The usual load of each engine was five eight-wheeled passenger cars, frequently carrying over one hundred passengers per car. On special occasions as many as six and seven loaded cars have been drawn by one of these engines.

"Each engine averaged fully sixteen trips daily, equal to fifty-six miles, and, as the stations were but a short distance apart, the Westinghouse air-brake was applied in making one hundred and sixty daily stops, or a total of twenty-five thousand for each engine. Neither engine was out of service an hour unless from accidents for which they were in no way responsible."

[NOTE.—Average weight of each loaded car about twelve gross tons.]

The year 1876 was also marked by an extension of locomotive engineering to a new field in the practice of these works. In the latter part of the previous year an experimental steam street-car was constructed for the purpose of testing the applicability of steam to street railways. This car was completed in November, 1875, and was tried for a few days on a street railway in Philadelphia. It was then sent to Brooklyn, December 25, 1875, where it ran from that time until June, 1876. One engineer ran the car and kept it in working order. Its consumption of fuel was between seven and eight pounds of coal per mile run. It drew regularly, night and morning, an additional car, with passengers going into New York in the morning, and returning at night. On several occasions, where speed was practicable, the car was run at the rate of sixteen to eighteen miles per hour.

In June, 1876, this car was withdrawn from the Atlantic Avenue Railway of Brooklyn, and placed on the Market Street Railway of Philadelphia. It worked with fair success, and very acceptably to the public on that line, from June till nearly the close of the Centennial Exhibition.

This original steam-car was built with cylinders under the body of the car, the connecting-rods taking hold of a crank-axle, to which the front wheels were attached. The rear wheels of the car were independent, and not coupled with the front wheels. The machinery of the car was attached to an iron bed-plate bolted directly to the wooden framework of the car body. The experiment with this car demonstrated to the satisfaction of its builders the mechanical practicability of the use of steam on street railways, but the defects developed by this experimental
car were: first, that it was difficult, or impossible, to make a crank-axle which would not break, the same experience being reached in this respect which had already presented itself in locomotive construction; second, it was found that great objection existed to attaching the machinery to the wooden car body, which was not sufficiently rigid for the purpose, and which suffered by being racked and strained by the working of the machinery.

For these reasons this original steam-car was reconstructed, in accordance with the experience which nearly a year's service had suggested. The machinery was made "outside-connected," the same as an ordinary locomotive, and a strong iron framework was designed, entirely independent of the car body, and supporting the boiler and all the machinery.

The car as thus reconstructed was named the "Baldwin," and is shown by the above illustration.

The next step in this direction was the construction of a separate "motor," to which one or more cars could be attached. Such a machine, weighing about sixteen thousand pounds, was constructed in the fall of 1876, and sent to the Citizens' Railway of Baltimore, which has the maximum grades of seven feet per hundred, or three hundred and sixty-nine and six-tenths feet per mile. It ascended the three hundred and sixty-nine feet grade, drawing one loaded car, when the tracks were covered with mixed snow and dirt to a depth of eight to
ten inches in places. Another and smaller motor, weighing only thirteen thousand pounds, was constructed about the same time for the Urbano Railway, of Havana, Cuba. Orders for other similar machines followed, and during the ensuing years 1877-78-79-80 one hundred and seven separate motors and twelve steam-cars were included in the product. Various city and suburban railways have been constructed with the especial view of employing steam-power, and have been equipped with these machines. One line, the Hill & West Dubuque Street Railway, of Dubuque, Iowa, was constructed early in 1877, of three and a half feet gauge, with a maximum gradient of nine in one hundred, and was worked exclusively by two of these motors. The details and character of construction of these machines are essentially the same as locomotive work, but they are made so as to be substantially noiseless, and to show little or no smoke and steam in operation.

Steel fire-boxes with vertical corrugations in the side sheets were first made by these works early in 1876, in locomotives for the Central Railroad of New Jersey, and for the Delaware, Lackawanna and Western Railway.

The first American locomotives for New South Wales and Queensland were constructed by the Baldwin Locomotive Works in 1877, and have since been succeeded by additional orders. Six locomotives of the "Consolidation" type for three and one-half feet gauge were also constructed in the latter year for the Government Railways of New Zealand, and two freight locomotives, six-wheels-connected with forward truck, for the Government of Victoria. Four similar locomotives (ten-wheeled,
six-coupled, with sixteen by twenty-four cylinders) were also built during the same year for the Norwegian State Railways.

Forty heavy "Mogul" locomotives (nineteen by twenty-four cylinders, driving-wheels four and one-half feet in diameter) were constructed early in 1878 for two Russian Railways (the Koursk Charkof Azof, and the Orel Griazi). The definite order for these locomotives was only received on the sixteenth of December, 1877, and, as all were required to be delivered in Russia by the following May, especial despatch was necessary. The working force was increased from eleven hundred to twenty-three hundred men in about two weeks. The first of the forty engines was erected and tried under steam on January 5th, three weeks after receipt of order, and was finished, ready to dismantle and pack for shipment, one week later. The last engine of this order was completed February 13th. The forty engines were thus constructed in about eight weeks, besides twenty-eight additional engines on other orders, which were constructed wholly or partially, and shipped during the same period.

The production during the years from 1872 to 1899 inclusive was as follows:

1872. . . . . 422 locomotives.
1873. . . . . 437 "
1874. . . . 205 "
1875. . . . 130 "
1876. . . . 232 "
1877. . . . 185 "
1878. . . . 292 "
1879. . . . 298 "
1880. . . . 517 "
1881. . . . 554 "
1882. . . . 563 " (6,000th locomotive completed.)
1883. . . . 557 " (7,000th locomotive completed.)
1884. . . . 429 "
1885. . . . 242 "
1886. . . . 550 " (8,000th locomotive completed.)
1887. . . . 653 "
1888. . . . 737 " (9,000th locomotive completed.)
1889. . . . 827 "
1890. . . . 946 " (11,000th locomotive completed.)
1891. . . . 899 locomotives. (12,000th locomotive completed.)
1892. . . . 731 " (13,000th locomotive completed.)
1893. . . . 772 "
1894. . . . 313 " (14,000th locomotive completed.)
1895. . . . 401 "
1896. . . . 547 " (15,000th locomotive completed.)
1897. . . . 501 "
1898. . . . 755 " (16,000th locomotive completed.)
1899. . . . 901 " (17,000th locomotive completed.)

Four tramway motors of twelve tons weight were built early in 1879, on the order of the New South Wales Government, for a tramway having grades of six per cent., and running from the railway terminus to the Sydney Exhibition Grounds. Subsequently orders have followed for additional motors for other tramways in Sydney.

The five thousandth locomotive, finished in April, 1880, presented some novel features. It was designed for fast passenger service on the Bound Brook line between Philadelphia and New York, and to run with a light train at a speed of sixty miles per hour, using anthracite coal as fuel. It had cylinders eighteen by twenty-four, one pair of driving-wheels six and one-half feet in diameter, and a pair of trailing-wheels forty-five inches in diameter, and equalized with the driving-wheels. Back of the driving-wheels and over the trailing-wheels space was given for a wide fire-box (eight feet long by seven feet wide inside) as required for anthracite coal. By an auxiliary steam cylinder placed under the waist of the boiler, just in front of the fire-box, the bearings on the equalizing beams between trailing- and driving-wheels could be changed to a point forward of their normal position, so as to increase the weight on the driving-wheels when required. The adhesion could thus be varied between the limits of thirty-five thousand to forty-five thousand pounds on the single pair of driving-wheels. This feature of the locomotive was made the subject of a patent.

In 1881, a compressed-air locomotive was constructed for the Pneumatic Tramway Engine Company, of New York, on plans prepared by Mr. Robert Hardie. Air-tanks of steel, one-half inch thick, with a capacity of four hundred and sixty-five cubic
feet were combined with an upright cylindrical heater, thirty-two and five-eighths inches in diameter. The weight of the machine was thirty-five thousand pounds, of which twenty-eight thousand pounds were on four driving-wheels, forty-two inches in diameter. The cylinders were twelve and a half inches diameter by eighteen inches stroke. Another novelty of the year was a steam-car to take the place of a hand-car. Accompanying illustration shows the design. Its cylinders were four by ten inches, and wheels twenty-four inches diameter. Built for standard gauge track, its weight in working order was five thousand one hundred and ten pounds. Similar cars have since been constructed. During this year the largest single order ever placed on the books was entered for the Mexican National Construction Company. It was for one hundred and fifty locomotives, but only a portion of them were ever built.

The year 1882 was marked by a demand for locomotives greater than could be met by the capacity of existing locomotive works. Orders for one thousand three hundred and twenty-one locomotives were entered on the books during the year, deliveries of the greater part being promised only in the following year. The six-thousandth locomotive was completed in January of this year, and the seven-thousandth in October, 1883.

Early in 1882 an inquiry was received from the Brazilian Government for locomotives for the Cantagallo Railway, which were required to meet the following conditions: To haul a train of forty gross tons of cars and lading up a grade of eight and three-tenths per cent. (four hundred and thirty-eight feet per mile), occurring in combination with curves of forty metres radius (one hundred and thirty-one feet radius, or forty-three and eight-tenths degrees). The line is laid with heavy steel rails, and the gauge is one and one-tenth metres, or three feet seven and one-third inches. The track upon which it was proposed to run
these locomotives is a constant succession of reverse curves, it being stated that ninety-one curves of the radius named occur within a distance of three thousand four hundred and twenty-nine metres, or about two miles. The line had previously been operated on the "Fell" system, with central rack rail, and it was proposed to introduce locomotives working by ordinary adhesion, utilizing the central rail for the application of brake power. An order was eventually received to proceed with the construction of three locomotives to do this work. The engines built were of the following general dimensions, viz.: Cylinders, eighteen by twenty inches; six driving-wheels connected, thirty-nine inches in diameter; wheel-base, nine feet six inches; boiler, fifty-four inches in diameter, with one hundred and ninety flues two inches diameter, ten feet nine inches long; and with side tanks, carried on the locomotive. In March, 1883, they were shipped from Philadelphia, and on a trial made October 17, in the presence of the officials of the road and other prominent railway officers, the guaranteed performance was accomplished. One of the engines pulled a train weighing forty tons, composed of three freight cars loaded with sleepers and one passenger car, and made the first distance of eight kilometres to Boca do Mato with a speed of twenty-four kilometres per hour; from there it started, making easily an acclivity of eight and five-tenths per cent. in grade, and against a curve of forty metres in radius. Eight additional locomotives for this line were constructed at intervals during the following ten years, and the road has been worked by locomotives with ordinary adhesion since their adoption as above described.

In 1885 a locomotive was built for the Dom Pedro Segundo Railway of Brazil, having five pairs of driving-wheels connected and a leading two-wheeled truck. From this has arisen the title "Decapod" (having ten feet) as applied to subsequent locomotives of this type. Its cylinders were twenty-two by twenty-six inches; driving-wheels forty-five inches diameter and grouped in a driving-wheel-base of seventeen feet. The rear flanged driving-wheels, however, were given one-quarter of an inch more total play on the rails than the next adjacent pair; the second and third pairs were without flanges, and the front pair was
flanged. The locomotive could therefore pass a curve of a radius as short as five hundred feet, the rails being spread one-half inch wider than the gauge of track, as is usual on curves. The flanges of the first and fourth pairs of driving-wheels, making practically a rigid wheel-base of twelve feet eight inches, determined the friction on a curve. The weight of the engine in working order was one hundred and forty-one thousand pounds, of which one hundred and twenty-six thousand pounds were on the driving-wheels. During this year the first rack-rail locomotive in the practice of these Works was constructed for the Ferro Principe do Grão Pará Railroad of Brazil. Its general dimensions were: Cylinders, twelve by twenty inches; pitch line of cog-wheel, 41.35 inches; weight, 15.74 tons. Several additional similar locomotives, but of different weights, have since been constructed for the same line.

At the close of this year, Mr. Edward Longstreth withdrew from the firm on account of ill health, and a new partnership was formed, adding Messrs. William C. Stroud, William H. Morrow, and William L. Austin. Mr. Stroud had been connected with the business since 1867, first as bookkeeper and subsequently as Financial Manager. Mr. Morrow, since entering the service in 1871, had acquired a varied and valuable experience, first in the accounts, then in the department of extra work, and subsequently as Assistant Superintendent, becoming General Manager on Mr. Longstreth's retirement. Mr. Austin, who entered the works in 1870, had for several years been assistant to Mr. Henszey in all matters connected with the designing of locomotives. The eight-thousandth locomotive was completed in June, 1886. A loco-
motive for the Antofogasta Railway (thirty inches gauge) of Chili, constructed with outside frames, was completed in November, 1886, and is illustrated on page 77. The advantages of this method of construction of narrow-gauge locomotives in certain cases were evidenced in the working of this machine, in giving a greater width of fire-box between the frames and a greater stability of the engine due to the outside journal bearings.

In 1887 a new form of boiler was brought out in some ten-wheeled locomotives constructed for the Denver and Rio Grande Railroad. A long wagon-top was used, extending sufficiently forward of the crown-sheet to allow the dome to be placed in front of the fire-box and near the centre of the boiler, and the crown-sheet was supported by radial stays from the outside shell. Many boilers of this type have since been constructed.

Mr. Charles T. Parry, who had been connected with the Works almost from their beginning and a partner since 1867, died on July 18, 1887, after an illness of several months.

The first locomotives for Japan were shipped in June, 1887, being two six-wheeled engines of three feet six inch gauge for the Mie Kie mines.

Mr. William H. Morrow, a partner since January 1, 1886, and who had been previously associated with the business since 1871, died February 19, 1888.

The demand for steam motors for street railway service attained large proportions at this period, and ninety-five were built during the years 1888 and 1889. Two rack-rail locomotives on the Riggenbach system, one with a single cog-wheel and four carrying-wheels, and weighing in working order thirty-two thousand pounds, for the Corcovado Railway of Brazil, and the other having two cog-wheels and eight carrying-wheels and weighing in working order seventy-nine thousand pounds, for the Estrada de Ferro Principe do Grão Pará of
Brazil, were constructed during this year. The general plans are shown by accompanying illustrations.

In October, 1889, the first compound locomotive in the practice of the Works was completed and placed on the Baltimore and Ohio Railroad. It was of the four-cylinder type, as designed and patented by Mr. S. M. Vauclain, who had been connected with the works since 1883 and its General Superintendent since February 11, 1886. The economy in fuel and water and the efficiency in both passenger and freight service given by this design led to its introduction on many leading railroads. Following the first four-cylinder compound locomotives built in 1889, three were built in 1890, eighty-two in 1891, two hundred and thirteen in 1892, one hundred and sixty in 1893, thirty in 1894, fifty-one in 1895, one hundred and seventy-three during 1896, eighty-six in 1897, two hundred and thirty-five in 1898, two hundred and forty-one in 1899.

In 1889 a test case was made to see in how short a time a locomotive could be built. On Saturday, June 22, Mr. Robert H. Coleman ordered a narrow-gauge "American" type passenger locomotive and tender, which it was agreed should be ready for service on his railroad in Lebanon County, Pa., by the fourth of July following. The boiler material was at once ordered and was received Tuesday, June 25. The boiler was completed and taken to the Erecting Shop on Friday, June 28, and on Monday, July 1, the machinery, frames, wheels, etc., were attached and the locomotive was tried under steam in the works. The tender was completed the following day, Tuesday, July 2, thus making the record of construction of a complete locomotive from the raw material of the art in eight working days.

The manufacture of wrought iron wheel-centres for both truck and driving-wheels was begun at this time under patents of Mr. S. M. Vauclain, Nos. 462,605, 462,606, and 531,487.

In 1890 the first rack-rail locomotive on the Abt system was constructed for the Pike's Peak Railroad, and during this year
and 1893 four locomotives were built for working the grades of that line, which vary from eight to twenty-five per cent. One of these locomotives, weighing in working order fifty-two thousand six hundred and eighty pounds, pushes twenty-five thousand pounds up the maximum grades of one in four. An illustration is here given of one of these locomotives, which is a four-cylinder "Compound."

Three "Mogul" locomotives, of one metre gauge, fifteen by eighteen cylinders, driving-wheels forty-one inches diameter, were completed and shipped in July, 1890, for working the Jaffa and Jerusalem Railway in Palestine, and two additional locomotives for the same line were constructed in 1892.

In 1891 the largest locomotives in the practice of the works were designed and constructed. For the St. Clair Tunnel of the Grand Trunk Railway, under the St. Clair River, four tank locomotives were supplied, each with cylinders twenty-two by twenty-eight; five pairs of driving-wheels connected, fifty inches diameter, in a wheel-base of eighteen feet five inches; boiler, seventy-four inches diameter; fire-box, eleven feet long by three and one-half feet wide; and tanks on the boiler of twenty-one hundred and ten gallons capacity. The weight in working order of each engine was one hundred and eighty-six thousand eight hundred pounds without fire in fire-box. The tunnel is six thousand feet long, with grades of two per cent. at each entrance, twenty-five hundred and nineteen hundred and fifty feet long respectively. Each locomotive was required to take a train load of seven hundred and sixty tons exclusive of its own
weight, and in actual operation each of these locomotives has hauled from twenty-five to thirty-three loaded cars in one train through the tunnel.

For the New York, Lake Erie and Western Railroad, five Compound locomotives of the "Decapod" class were completed in December, 1891. Their general dimensions were as follows: Cylinders, high pressure sixteen inches, low pressure twenty-seven inches diameter, stroke twenty-eight inches; five pairs of driving-wheels coupled fifty inches diameter in a wheel-base of eighteen feet ten inches; boiler seventy-six inches diameter; three hundred and fifty-four tubes, two inches diameter, twelve feet long; fire-box (Wootton type) eleven feet long, eight feet two inches wide inside; combustion chamber thirty-six inches long; weight in working order one hundred and ninety-five thousand pounds, weight on driving-wheels one hundred and seventy-two thousand pounds; weight of eight-wheeled tender with fuel and four thousand five hundred gallons of water, eighty-nine thousand four hundred and twenty pounds. The first, fourth, and fifth pairs of driving-wheels were flanged, but the fifth pair had one-fourth inch additional play on the track. These locomotives are used as pushers on the Susquehanna Hill, where curves of five degrees are combined with grades of sixty feet per mile, doing the work of two ordinary "Consolidation" locomotives. From one thousand two hundred and fifty to one thousand three hundred net tons of cars and lading, making a train of forty-five loaded cars, are hauled by one of these locomotives in connection with a twenty by twenty-four cylinder "Consolidation."

Mr. William C. Stroud, who had been a partner since 1886, died on September 21, 1891.

The first locomotives for Africa were constructed during this year. They were of the "Mogul" type, with cylinders eighteen by twenty-two inches, driving-wheels forty-eight inches diameter, and for three feet six inches gauge.
The product for 1892 and 1893 included, as novelties, two rack-rail locomotives for a mountain railway near Florence, Italy, and twenty-five compound "Forney" locomotives for the South Side Elevated Railroad, of Chicago. At the World's Columbian Exposition in Chicago, May to October inclusive, an exhibit was made consisting of seventeen locomotives, as follows:

**Standard Gauge.**—A Decapod locomotive, similar to those above described, built in 1891 for the New York, Lake Erie and Western Railroad. A high-speed locomotive of new type, with Vauclain compound cylinders, a two-wheel leading truck, two pairs of driving-wheels, and a pair of trailing wheels under the fire-box. This locomotive was named "Columbia," and the same name has been applied to the type. An express passenger locomotive of the pattern used by the Central Railroad of New Jersey; one of the pattern used by the Philadelphia and Reading Railroad, and one of the pattern used by the Baltimore and Ohio Railroad. The three roads mentioned operate together the "Royal Blue Line" between New York and Washington. A saddle tank double-ender type locomotive, with steam windlass, illustrating typical logging locomotive practice. A single expansion 18x24 cylinder American type locomotive. A single expansion 19x24 cylinder Mogul locomotive. A single expansion 20x24 cylinder ten-wheel freight locomotive for the Baltimore and Ohio Southwestern Railroad. A compound ten-wheel passenger locomotive shown in connection with a train exhibited by the Pullman Palace Car Company. A compound Consolidation locomotive for the Norfolk and Western Railroad. Three locomotives were shown in connection with the special exhibit of the Baltimore and Ohio Railroad, viz., one compound, one single expansion, and one ten-wheel passenger locomotive.

**Narrow-Gauge.**—A one-metre-gauge compound American type locomotive; a three-foot-gauge ten-wheel compound locomotive, with outside frames, for the Mexican National Railroad; and a thirty-inch-gauge saddle tank locomotive for mill or furnace work.

The depression of business which began in the summer of 1893, reduced the output of the works for that year to seven hundred and seventy-two, and in 1894 to three hundred and
thirteen locomotives. Early in 1895, a new type of passenger locomotive was brought out, illustrated by annexed cut. To this the name “Atlantic” type was given. The advantages found in this design are a large boiler, fitting the engine for high speed;

![Atlantic Type](image)

... a fire-box of liberal proportions and a desirable form placed over the rear frames, but of ample depth and width; and the location of the driving-wheels in front of the fire-box, allowing the boiler to be placed lower than in the ordinary “American” or “Ten-wheeled” type. For the enginemen, who, in this class of locomotive, ride behind, instead of over the driving-wheels, greater ease in riding, and greater safety in case of the breakage of a side-rod, are important advantages.

The first electric locomotive was constructed in 1895, and was intended for experimental work for account of the North American Company. The electrical parts were designed by Messrs. Sprague, Duncan & Hutchison, Electrical Engineers, New York. Two other electric locomotives for use in connection with mining operations were built in 1896, in co-operation with the Westinghouse Electric Manufacturing Company, which supplied the electrical parts.

A high-speed passenger locomotive, embracing several novel features, was built in 1895, for service on the New York division of the Philadelphia and Reading Railroad. The boiler was of
the Wootten type, the cylinders were compound, thirteen and twenty-two by twenty-six, and the driving-wheels (one pair) were eighty-four and one-quarter inches diameter. The cut below shows the general design.

**High-Speed Locomotive.**

The weight of the engine in working order was as follows: On front truck, thirty-nine thousand pounds; on trailing wheels, twenty-eight thousand pounds; on the driving-wheels, forty-eight thousand pounds. This locomotive and a duplicate built in the following year have been regularly used in passenger service, hauling from five to eight cars, and making the distance between Jersey City and Philadelphia, ninety miles, in one hundred and five minutes, including six stops.

In July, 1895, a combination rack and adhesion locomotive was constructed for the San Domingo Improvement Company, having compound cylinders eight inches and thirteen inches diameter by eighteen inches stroke to operate two pairs of coupled adhesion wheels, and a pair of single expansion cylinders, eleven inches by eighteen inches, to operate a single rack-wheel constructed upon the Abt system.

This locomotive was furnished with two complete sets of machinery, entirely independent of each other, and was built with the view eventually to remove the rack attachments and operate the locomotive by adhesion alone.

During the years 1895 and 1896 contracts were executed for several railroads in Russia, aggregating one hundred and thirty-eight locomotives of the four-cylinder compound type.
On January 1, 1896, Samuel M. Vauclain, Alba B. Johnson, and George Burnham, Jr., were admitted to partnership.

Two combination rack and adhesion locomotives were built in 1896 for the Peñoles Mining Company, of Mexico, having compound cylinders nine and one-half and fifteen inches diameter by twenty-two inches stroke, connected to the driving-wheels through walking-beams. Two pairs of wheels are secured to the axles by clutches and act as adhesion driving-wheels, and the rear wheels are loose on the axle and act only as carrying wheels. All three coupled axles carry rack pinions of the Abt system. The two pairs of adhesion wheels are thrown into operation by means of the clutches.

In the latter part of the year 1896, six locomotives were built for the Baltimore and Ohio Railroad, for express passenger service. One of these locomotives, No. 1312, is here illustrated. They are the "Ten-wheel" type, with cylinders twenty-one by twenty-six inches, driving wheels seventy-eight inches diameter, and weigh in working order about one hundred and forty-five thousand pounds, about one hundred and thirteen thousand pounds of which is on the driving wheels. These locomotives have handled the fast passenger trains on the Baltimore and Ohio Railroad running between Philadelphia, Baltimore and Washington with great efficiency.
In the summer of 1897, the Reading Railway placed a fast train on its Atlantic City Division, allowing fifty-two minutes for running time from Camden to Atlantic City, a distance of fifty-five and one-half miles, making the average rate of speed sixty-four miles per hour. The trains averaged five and six cars, having a total weight of about two hundred tons, not including the engine and tender. This train is hauled by locomotive No. 1027 of the Atlantic type, having Vauclain compound cylinders, thirteen and twenty-two inches in diameter by twenty-six inches stroke, with driving-wheels eighty-four and one-quarter inches, and weighing in working order on driving-wheels seventy-eight thousand six-hundred pounds, the total weight of engine and tender complete being two hundred and twenty-seven thousand pounds. The records show that for fifty-two days from July 2nd to August 31, 1897, the average time consumed on the run was forty-eight minutes, equivalent to a uniform rate of speed from start to stop of sixty-nine miles per hour. On one occasion the distance was covered in forty-six and one-half minutes, an average of seventy-one and six-tenths miles per hour. The same train was continued in service during the season of 1898 and 1899 with equal results.
In November, 1898, a locomotive was built for the Lehigh Valley Railroad for use on the mountain cut-off between Coxton and Fairview, near Wilkesbarre.

This locomotive is of the Consolidation type, with Vauclain compound cylinders, and of the general dimensions following: Cylinders, eighteen and thirty inches diameter, thirty inches stroke, driving-wheels, fifty-five inches outside diameter; boiler, Wootten type, eighty inches diameter at smallest ring, with a total heating surface of four thousand one hundred and five square feet; weight in working order, on drivers, two hundred and two thousand two hundred and thirty-two pounds; weight, total engine, two hundred and twenty-six thousand pounds. Tank capacity, seven thousand gallons.

![Atlantic Type Locomotive. For Chicago, Burlington and Quincy R. R.](image)

Weight of engine and tender about three hundred and forty-six thousand pounds. This locomotive was guaranteed to haul a load of one thousand net tons, exclusive of the weight of the engine and tender, on a grade of sixty-six feet per mile at an average speed of seventeen miles per hour. It fulfilled this guarantee and fourteen similar locomotives were subsequently ordered by this Company.

In March, 1899, two locomotives were built for the Chicago, Burlington & Quincy Railroad, for the fast mail service west of Chicago. These were of the "Atlantic" type with Vauclain compound cylinders, thirteen and one-half and twenty-three inches in diameter and twenty-six inches stroke, driving-wheels eighty-four and one-quarter inches in diameter, weight in working order eighty-five thousand eight hundred and fifty pounds on driving-wheels, and one hundred and fifty-nine thousand pounds total of engine. The total weight of engine
and tender complete is about two hundred and fifty-four thousand pounds.

Dr. Edward H. Williams, who had been connected with the Works as a partner since 1870, died December 21, 1899, at Santa Barbara, California.

The year 1899 was marked by a large increase in foreign business, notably in England and France. Contracts were made in England covering thirty locomotives for the Midland Railway, twenty locomotives for the Great Northern Railway, and twenty locomotives for the Great Central Railway. Ten locomotives were also ordered by the French State Railways, and ten by the Bone Guelma Railway, in the French colonies of Algiers.

The record of the Baldwin Locomotive Works has thus been given for sixty-eight years of existence and continuous operation. Over seventeen thousand locomotives have been constructed since the "Old Ironsides," in 1831. That engine was nearly a year in building.

The following figures indicate the growth of the Works:

<table>
<thead>
<tr>
<th>Works established</th>
<th>1831</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000th locomotive built</td>
<td>1861</td>
</tr>
<tr>
<td>2,000th</td>
<td>1869</td>
</tr>
<tr>
<td>3,000th</td>
<td>1872</td>
</tr>
<tr>
<td>4,000th</td>
<td>1876</td>
</tr>
<tr>
<td>5,000th</td>
<td>1880</td>
</tr>
<tr>
<td>6,000th</td>
<td>1882</td>
</tr>
<tr>
<td>7,000th</td>
<td>1883</td>
</tr>
<tr>
<td>8,000th</td>
<td>1886</td>
</tr>
<tr>
<td>9,000th</td>
<td>1888</td>
</tr>
<tr>
<td>10,000th</td>
<td>1889</td>
</tr>
<tr>
<td>11,000th</td>
<td>1890</td>
</tr>
<tr>
<td>12,000th</td>
<td>1891</td>
</tr>
<tr>
<td>13,000th</td>
<td>1892</td>
</tr>
<tr>
<td>14,000th</td>
<td>1894</td>
</tr>
<tr>
<td>15,000th</td>
<td>1896</td>
</tr>
<tr>
<td>16,000th</td>
<td>1898</td>
</tr>
<tr>
<td>17,000th</td>
<td>1899</td>
</tr>
</tbody>
</table>
It will be seen from the foregoing that, while thirty years were occupied in building the first thousand engines, almost as many were built in the single year of 1890.

The present organization, based upon an annual capacity of one thousand locomotives, equal to three and one-third locomotives per working day, is as follows:

Number of men employed.......................... 8,000
Hours of labor per man per day................... 10
Principal departments run continuously,}
hours per day ................................. 23
Horse-power employed ............................ 6,000
Number of buildings comprised in Works......... 29
Acreage comprised in works........................ 16
Number of dynamos for furnishing power, H.-P. 1,600
-------------------------
Number of dynamos for lighting....
| 6 Arc
| 4 Incandescent
Number of electric lamps in service...
| 3,000 Incandescent
| 300 Arc
Horse-power of electric motors employed for
power transmission, aggregate H.-P. ............. 3,000
Consumption of coal, in net tons, per week,
approximately ................................... 1,200
Consumption of iron, in net tons, per week,
approximately ................................... 2,000
Consumption of other materials, in net tons
per day, approximately .......................... 100

The location, in the largest manufacturing city in America, gives especial facilities and advantages. Proximity to the principal coal and iron regions of the country renders all required materials promptly available. A large permanent population of skilled mechanics, employed in similar branches in other Philadelphia workshops, gives an abundant force of expert workmen from which to draw when necessary. All parts of locomotives and tenders, except the boiler and tank plates, the steel tires, and steel castings, chilled wheels, boiler tubes and special patented appliances, are made in the Works from the raw materials.
PREFACE TO CATALOGUE.

THE following pages present and illustrate a system of Narrow-Gauge Locomotives, in which it is believed will be found suitable designs for all ordinary requirements of service.

These patterns admit of modifications to suit the preferences of railroad managers, and where locomotives of peculiar construction for special service are required, designs will be prepared and submitted or locomotives built to specifications furnished.

The locomotives of the system herewith presented are adapted to the consumption as fuel of wood, coke, or bituminous coal.

By the system of manufacture employed, all important parts are accurately made to gauges and templates; they are therefore interchangeable throughout any number of locomotives of the same class. This system permits of any parts needed for repairs being supplied either with the locomotive or whenever subsequently required. Such parts are made to the same gauges and templates which were originally used in the construction of the locomotive, and in this manner the expense of repairs is reduced to a minimum and the maintenance of locomotive power is attended with the least possible inconvenience and delay. It is only necessary to give the construction number of the locomotive and describe the part which is required, and it can be furnished from the works at the shortest notice, guaranteed to fit in place.

Particulars are given of the hauling capacity of the various classes illustrated, based upon actual work done. The basis of these calculations is a factor of adhesion of nine-fortieths (or say .225) of the weight on driving-wheels, whilst the maximum mean effective pressure on pistons at slow speed is taken at eighty per cent. of the nominal boiler pressure. It is assumed that the frictional resistance of the cars hauled will not exceed eight pounds per ton of 2240 pounds. These conditions are taken as those prevailing under ordinarily favorable conditions, with track and cars in good order, and exclusive of the resistance of curves. Allowance may be made for curvature by considering each degree of curvature as equivalent to the resistance of straight grade, at the rate of one and one-half feet rise per mile. One
Hauling Capacity in Tons (or 2240 lbs) for each 1000 lbs. on Driving Wheels
The weight of the locomotive is included in the load, slow speed, and straight tracks, are assumed.

[Graph showing the relationship between Adhesion Resistance and Tons hauled per 1000 lbs. on driving wheels, with Per Cent Grade on the x-axis and Tons hauled on the y-axis.]
degree of curvature is 5730 feet radius. Therefore the actual radius divided into 5730 gives the number of degrees of any curve.

The diagram on page 91 shows graphically the number of tons (of 2240 pounds) which should be hauled on grades from level to 4.5 per cent., at slow speed, by any locomotive, inclusive of the weight of the engine and tender, for each 1,000 pounds weight on driving-wheels. The weight of engine and tender, in tons of 2240 pounds, must be deducted to get the weight of cars and lading. Five bases of calculation are shown by separate lines in this diagram. Under the most favorable conditions, such as well-surfaced track, dry rails, well lubricated rolling-stock, etc., adhesion equal to one-fourth or ten-fortieths of the weight on driving-wheels may be developed; but as these conditions cannot at all times be realized, the loads given in the following tables are based on the second line, or nine-fortieths the weight on driving-wheels. Even this basis, which may be considered as representing average excellent conditions, is more favorable than frequently prevails on narrow-gauge lines having light rails or poorly laid track, logging railroads, etc. The other three lines are added to the diagram to make provision for such cases. The selection of the basis of calculation must of course be made in each instance with reference to the actual or probable condition of the road and its rolling equipment.

Designs and estimates for any sizes or patterns of locomotives not given in this catalogue will be submitted on application. The delivery of locomotives at any point which can be reached by rail or vessel will be included in contracts if desired.

In ordering locomotives the following particulars should be given:

1. Gauge of track,—exact distance between the rails.
2. Kind of fuel which will be used.
3. Kind and height of couplings of cars.
4. Limitations, if any, in height and width, by tunnels, overhead bridges, etc.
5. Mark, name, or number.

The A B C Code (Fourth Edition, 1881), the A I Code, Lieber's Code, the Vanguard Code or Baldwin Locomotive Works' private code may be employed in telegraphing.
GENERAL SPECIFICATIONS.

The materials used in the construction of locomotives conform to the physical and chemical requirements given below. All purchases are made upon the basis of these specifications, and the conformity of all materials therewith is carefully verified in a well-equipped testing laboratory. Likewise numerous tests are made daily of the cast iron and other materials manufactured in the Works. Complete records are kept for each locomotive, and in the event of accident or litigation accurate testimony can be furnished.

PHYSICAL TESTS OF MATERIALS.

All materials shall be of the best quality of their respective kinds, carefully inspected, and subjected to the following tests. Notwithstanding these tests, should any defects be developed in working, the corresponding part will be rejected.

Boiler and Fire Box Steel. All plates must be rolled from steel manufactured by the open hearth process, and must conform to the following chemical analysis:

<table>
<thead>
<tr>
<th>Carbon, between</th>
<th>0.15 and 0.25 per cent.</th>
<th>0.15 and 0.25 per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus, not over</td>
<td>0.05 per cent.</td>
<td>0.03 per cent.</td>
</tr>
<tr>
<td>Manganese, not over</td>
<td>0.45 &quot;</td>
<td>0.45 &quot;</td>
</tr>
<tr>
<td>Silicon, not over</td>
<td>0.03 &quot;</td>
<td>0.03 &quot;</td>
</tr>
<tr>
<td>Sulphur, not over</td>
<td>0.05 &quot;</td>
<td>0.035 &quot;</td>
</tr>
</tbody>
</table>

No sheets will be accepted that show mechanical defects. A test strip taken lengthwise from each sheet rolled and without annealing should have a tensile strength of 60,000 pounds per square inch, and an elongation of 25 per cent., in section originally 8 inches long. Sheets will not be accepted if the test show a tensile strength less than 55,000 pounds, or greater than 65,000 pounds, per square inch, nor if the elongation fall below 20 per cent.

Boiler Iron. All boiler iron plates are to be of C. H. No. 1 Flange quality, and to be made from best charcoal iron blooms. A careful examination will be made of every plate, and none will be accepted that show mechanical defects.
All boiler iron to be C. H. No. 1 Flange quality, and must be made from the best charcoal blooms, and must be free from mechanical defects. Should any plates develop defects in working, they will be rejected.

A test piece to be furnished from each sheet, which must show an ultimate tensile strength with the grain of not less than 50,000 pounds, an ultimate tensile strength across the grain of not less than 45,000 pounds, and must show an elongation of not less than 20 per cent. A drifting test will be made of at least two pieces. No plates will be accepted which will not permit of a 1\(\frac{3}{4}\)" hole being drifted out cold to 3" diameter. Each plate must be stamped with the maker's name and the guaranteed tensile strength and elongation as above.

**Fire Box Copper.** Copper plates for fire boxes must be rolled from best quality Lake Superior ingots; they must have a tensile strength of not less than 30,000 pounds per square inch, and an elongation of at least 20 per cent., in section originally 2 inches long. Test strips must be furnished with each fire box for testing.

**Stay Bolt Iron.** Iron for stay bolts must be double refined, and show an ultimate tensile strength of at least 48,000 pounds per square inch, with a minimum elongation of 25 per cent., in a test section 8 inches long. Pieces 24 inches long must stand bending double, both ways, without showing fracture or flaw. Iron must be rolled true to gauges furnished, and permit of cutting a clean, sharp thread.

**Copper Stay Bolts.** Copper stay bolts must be manufactured from the best Lake Superior ingots; they must have an ultimate tensile strength of not less than 30,000 pounds per square inch, and an elongation of at least 20 per cent., in section originally 2 inches long.

**Boiler Tubes of Charcoal Iron.** All boiler tubes must be carefully inspected and be free from pit-holes or other imperfections. Each tube must be subjected by the manufacturers, before delivery, to an internal hydraulic pressure of not less than 500 pounds per square inch. They must be rolled accurately to the gauge furnished by the Baldwin Locomotive Works, filling the gauge to a plump fit. They must be expanded in the boiler without crack or flaw.

A test section 1\(\frac{3}{4}\) inches long, cut from any tube, must permit
of vertical hammering without showing transverse cracks when flattened down.

**Boiler Tubes of Brass or Copper, Brass and Copper Pipes.** Tubes of brass or copper to be of uniform circumferential thickness and solid drawn; to be perfectly round and to resist an internal hydraulic pressure of 300 pounds per square inch. From the tubes under test a piece 4 inches long will be cut, annealed, sawed lengthwise, and doubled inside out without showing sign of cracks.

When annealed they must withstand flanging cold, without cracking, a flange $\frac{5}{8}$ of an inch broad for 2-inch tubes. Copper tubes must withstand flanging hot as well as cold. Tubes other sizes than 2 inches diameter must flange to a width proportional to their diameter.

A piece 30 inches long, annealed, and filled with rosin, must withstand being doubled until the extremities touch each other without showing defects.

A piece 30 inches long, not annealed, filled with rosin, and placed on supports 20 inches apart, must withstand bending to a deflection of 3 inches without showing defects.

**Bar Iron.** Bar iron should have a tensile strength of 50,000 pounds per square inch, and an elongation of 20 per cent., in section originally 2 inches long. Iron will not be accepted if tensile strength falls below 48,000 pounds, nor if elongation is less than 15 per cent., nor if it shows a granular fracture.

**Steel Tank Plates.** Tank plates to be rolled from homogeneous steel billets, and must be of good finish, free from surface defects, such as spalling or bad buckling. The steel to be of such quality that pieces taken lengthwise of any plate selected shall show no sign of fracture when bent double cold over a mandril whose diameter is one and a half times thickness of plate so tested.

**Steel for Forgings.** All blooms for use in axles, pins, rods, guides, and similar forgings, must be made by the open-hearth process, and be free from seams, slivers, and other surface defects. No chipping will be permitted for the removal of such defects.

Drillings will be taken from a point midway between the center and the surface of the bloom, and must conform to the following specifications when analyzed by Baldwin Locomotive Works standard methods:
Carbon . . . . . . 0.37 to 0.40
Manganese, not over . . . . . . 0.60
Phosphorous . . . . . . 0.05
Sulphur, about . . . . . . 0.05

These blooms should be of such quality that a test-piece machined cold from a full-sized bloom of each heat used in filling our orders should, when tested, have an ultimate tensile strength of 80,000 pounds per square inch, and an elongation of 20 per cent., in a test section originally 2 inches long.

Blooms will not be accepted that show an ultimate tensile strength of less than 75,000 or more than 90,000 pounds per square inch, or an elongation of less than 15 per cent.

All forgings which develop seams or pipes upon machining will be returned, and must be replaced by new blooms at the expense of the manufacturer.

Chilled Wheels. Of approved make, and of following guaranteed mileage:

For 28" wheels . . . . 40,000 miles.
" 30" " . . . . 45,000 "
" 33" " . . . . 50,000 "

Other sizes in proportion.

(Adopted by Joint Committee of Master Car Builders' Association, American Railway Master Mechanics' Association, and Association of Manufacturers of Chilled Car Wheels, November 21, 1889.)

Deficient mileage will be adjusted upon return of the defective wheel, or that part of same containing the defect causing withdrawal from service. Or, if preferred, wheels will be furnished subject to approved specification and drop test, without mileage guarantee.

Spring Steel. All spring steel must be manufactured by the crucible process, and must be free from any physical defects. The metal desired has the following composition:

Carbon . . . . . . 1.00 per cent.
Manganese . . . . . . 0.25 "
Phosphorous, not over . . . . . . 0.03 "
Silicon, not over . . . . . . 0.15 "
Sulphur, not over . . . . . . 0.03 "
Copper, not over . . . . . . 0.03 "
Steel will not be accepted which shows on analysis less than 0.90 or over 1.10 per cent. of carbon, or over 0.50 per cent. of manganese, 0.05 per cent. of Phosphorus, 0.25 per cent. of silicon, 0.05 per cent. of sulphur, and 0.05 per cent. of copper.

Phosphor Bronze. All bronze to be made from new metals, and should show the following analysis:

- Copper . . . . . . 79.70 per cent.
- Tin . . . . . . . . 10.00 "
- Lead . . . . . . . . 9.50 "
- Phosphorus . . . . . . 0.80 "

Bronze will be rejected should analysis show results outside the following limits:

- Tin . . . . below 9.00 per cent. or over 11.00 per cent.
- Lead . . 8.00 " " 11.00 "
- Phosphorus " 0.70 " " 1.00 "

Bronze will also be rejected in case it contains 0.50 per cent. of any other substances than the four elements mentioned in this specification.

Steel Tires. All tires to be made of dense, homogeneous bottom-poured ingots, and to insure freedom from pipes, segregations and other imperfections, the steel must be cast in long, hexagonal ingots, and not less than 20 per cent. of the weight of the ingot must be discarded from the top portion.

Tires supported in running position on an anvil weighing at least 10 tons, and subjected to repeated blows of a tup weighing 2,240 pounds, must show a minimum deflection of \( \frac{1}{16} \) the internal diameter for all tires exceeding 36" internal diameter, of \( \frac{1}{16} \) the internal diameter for all tires exceeding 24" internal diameter and not more than 36", and of \( \frac{1}{14} \) the internal diameter for all tires less than 24" internal diameter.

A test piece cut cold from tire must show a tensile strength of 108,000 to 120,000 pounds per square inch, and a reduction of area of 15 per cent. The elongation measured in a 2" section to be not less than 12 per cent. for the minimum tensile strength.

Tires will be rejected if the following maximum limits are exceeded:

- Manganese . . . . . . . .75 per cent.
- Phosphorus . . . . . . . .05 per cent.
- Sulphur . . . . . . . . .05 per cent.
Baldwin Locomotive Works.

Burnham, Williams & Co.

Philadelphia.................................

Class.................................]  [Drawing No ..................

SPECIFICATION.

No. ..................

Of a................................................................. Locomotive Engine, having.............. pairs of coupled wheels and a............... wheeled........ truck; for the............................................................... Company. (This specification may be referred to in cabling by code word... .... )

Design. General design illustrated by attached photograph of engine .................................................................

Dimensions. Cylinders. High-pressure cylinders............ inches diameter and........... .... inches stroke.

Low-pressure cylinders............ inches diameter and............ inches stroke.

Driving Wheels............ inches diameter. Gauge ............. feet........... inches. Fuel .............................................

Wheelbase. Total wheelbase .... feet .... inches. Driving wheelbase.......... feet ........... inches.

Total wheelbase of locomotive and tender not to exceed ............. feet ........... inches.
Weight. In working order, total about...............lbs.; on driving-wheels, about.........lbs.

Weight of tender, with fuel and water, about.........................pounds.

Limits. Of height.............feet...............inches; of width ..............feet...............inches.

Boiler. Made of plates of homogeneous steel for a working pressure of........pounds per square inch, and tested with steam to at least 20 pounds per square inch above working pressure, and with hot water to one-third above the working pressure. Waist..........inches in diameter at smoke-box end; made.................top, with one dome placed.............................. Waist plates...............inch thick; all longitudinal seams.............

All boiler and fire-box seams caulked inside and outside where possible. All holes reamed perfectly true after sheets are put together, holes slightly countersunk on inside and outside edges. No hand riveting permitted except where it is impossible to use power riveters. Throat sheet of sufficient thickness to prevent undue thinning where flanged. All parts well and thoroughly stayed. Liners on inside of side sheets, providing double thickness of metal for studs of expansion braces, if side-sheets are less than nine-sixteenths of an inch thick. All calking edges of plates planed where possible and caulked with round-pointed calking tool, insuring plates against injury by chipping in calking with sharp-edged tools. All boiler brace jaws drop forged, with holes drilled. All rivet and pinholes in braces to be drilled. All jaw pins to be turned to give full body bearing on both sides of jaw, and to be held in position by nut, washer and cotter-pin. All T-irons fastened to the interior of boiler-shell to be machined accurately to fit the radius of boiler. Tube sheets to be thoroughly annealed and tube holes accurately reamed to gauges. Sharp corners carefully rounded to avoid cutting tubes in setting.

Dome. Dome Ring (A) to be of seamless open hearth forged steel, turned and accurately fitted to the interior of dome sheet
before being drilled and riveted. Dome Cap (B) to be of forged steel. Dome Base (C) to be of seamless open hearth forged steel, flanged and radially planed to fit the outer shell of boiler. The interior bored to receive the body sheet of dome. All rivets connecting dome to boiler to be driven by hydraulic pressure. The body sheet of the dome (D) to be seamless open-hearth steel, fitted over dome ring by shrinkage.

**Tubes.**

No. .................. wire gauge, with copper ferrules on swaged ends in fire box tube-sheet ......................... in number ...................... inches in diameter, and ...................... feet ...................... inches in length.

**Fire-box.** .................. inches long and .................. inches wide inside; of homogeneous steel, all flanged plates thoroughly annealed after flanging; side and back sheets, .................. inch thick. Crown sheet .................. inch thick; flue sheet, one-half inch thick. Water space .................. inches sides and back, .................. inches front. Outside and inside surfaces of water-space frame, against which the sheets of the fire box and outer shell are riveted, to be machined smooth and fitted to gauges. Corners to be machined to fit lap of sheets, no scarfing of sheet at joint permitted. Rivets through water-space frame countersunk both inside and outside, in order that the shrinking of the
rivets shall tighten the sheet rather than have a tendency to pull off the head. The vertical seams at the throat and back sheets to have countersunk rivets both inside and outside, to allow full width of water space and to admit of removal of boiler without dismantling frames. Stay bolts of iron

inch diameter, screwed and riveted to sheet, and not over four and one-half inches from centre to centre. All stay-bolts to have three-sixteenths-inch hole, one and one-quarter inches deep from outside, to indicate when broken in service. All stay-bolts threads turned off between sheets. Fire-door opening formed by flanging and riveting together the inner and outer sheets. Tool guard to be cast on lower part of fire-door frame. Fire-brick arch

Crown Staying. Crown Sheet supported by Crown bars, each made of two pieces of wrought iron inches by inches, set one and one-half inches above crown, placed not over four and one-half inches from centre to centre, and bearing on side sheets. Crown bar bolts not over four and one-half inches from centre to centre, with head on under side of crown-sheet. Crown-bars stayed by braces to outside shell of boiler, or

By bars inches by inches, placed not less than three inches above crown and not over eight inches apart from centre to centre, bolts with taper fit through crown sheet and not over four and one-half inches from centre to centre. bars supported by wrought iron thimbles and stayed by braces to outside shell of boiler, or
By Radial Stay-bolts .......... inches diameter, not over four and one-half inches from centre to centre, screwed through crown sheet and roof of boiler, and riveted over. Front end of crown sheet to be supported by sling stays.

Steam Pipes. Dry steam pipe inside boiler of wrought iron. Steam pipes in smoke box of cast iron.

Cleaning Holes. Cleaning plugs located where necessary for proper cleaning of boilers.

Corner wash-out holes when placed diagonally, to be re-inforced by flanging sheet outward and tapping interior of flange to receive plug.

Throttle Valve. Balanced puppet throttle valve of cast iron, in vertical arm of dry-pipe.

Grates, etc. Grates .................................. Ash-Pan .................................. Smoke Stack. ..........................................................

Smoke Box. Extended, with netting, deflecting plate, and spark ejector or spark hopper.

Frames. Of hammered iron or cast steel, made in two sections.

Front rails bolted and keyed to main frames, and with front and back lugs forged on for cylinder connections.

Pedestals. Pedestals in one piece with main frames and protected from wear of boxes by cast iron gibs and wedges. Pedestal cap lugged and bolted to bottom of pedestals.

Engine-Truck. Centre-bearing swivelling .......... wheeled truck

...................................................

Frame. Truck frame of wrought iron, with braces of wrought iron; fitted with swinging bolster or with fixed centre-bearing.

Wheels. ............................................ wheels, .......... inches diameter.
Axles. Of hammered steel with journals.............. inches in diameter and.............. inches long.

Springs. Of crucible cast steel tempered in oil, connected by equalizing beams resting on top of boxes.

Cylinders. Of close-grained iron as hard as can be worked; each cylinder cast in one piece with half-saddle, and placed horizontally; right- and left-hand cylinders reversible and interchangeable; accurately planed, fitted, and bolted together in the most approved manner. Valve face and steam chest seat raised above face of cylinder to allow for wear, except when piston valves are used. Cylinders oiled by automatic sight feed lubricator placed in cab, and connected to steam chests by copper pipes running under jacket. Pipes proved to 300 pounds pressure.

Pistons. Pistons of cast iron, fitted with approved form of steam packing. Piston-Rods of iron or steel, ground and keyed to cross-heads, and securely fastened to pistons.

Packing. Metallic packing for piston rod and valve-stems.

Guides. Of steel, cast iron, or wrought iron case hardened, fitted to wrought iron guide-yoke.

Cross Heads. Of..............................with suitable bearings..............................

Valve Motion. Shifting link motion, graduated to cut off equally at all points of stroke. Links, sliding-blocks, pins, lifting links, and eccentric rod jaws made of hammered iron, well case hardened. Sliding blocks with long flanges to give ample wearing surface. Rock shafts of wrought iron; reverse shaft of wrought iron. Slide valves............................................

Driving Wheels..........in number;.............. inches in diameter. Centres of cast.......... turned to.............. inches diameter.

Tires. Of cast steel.............. inches thick when finished;.............. pairs flanged.............. inches wide;.............. pairs plain-

Axles. Of hammered steel; journals.............. inches diameter and.............. inches long. Driving-Boxes of cast iron, with brass bearings.
Springs. Of crucible cast steel, tempered in oil. Equalizing beams of wrought iron or cast steel.

Rods. Connecting and Parallel Rods of hammered steel. Connecting rods forged solid, and furnished with all necessary straps, keys and brasses. Parallel rods with straps, keys, and brasses or with solid ends and heavy brass bushings. Bushings put in by hydraulic press, and well secured from turning in rod.

Oil-Cups. Lubrication of all bearings carefully provided for, and oil-cups attached where required. Wick, plunger or adjustable needle oil-cups on rods and guides.

Wrist Pins. Wrist-Pins of steel.

Feed Water. Supplied by.................................injectors.

Cab. Substantially built of clear, sound ash, or clear pine, well finished, and fitted together with joint bolts and corner plates. To be provided with suitable windows and doors, conveniently arranged, and glazed with first quality double American crystal glass. Cab seats, cab seat cushion and an engineer's arm rest to be provided.

Pilot. Of wood braced with iron..........................

Furniture. Engine to be furnished with.........................sand-box

............................., sander, bell and bell cord, one extra fusible plug, engineer's torch.

Boiler Fittings: Whistle, blow-off cock, blower valve, safety valves, steam gauge with lamp, and gauge cocks.

Tools: Two heavy jack screws and levers, one heavy pinch bar with steel point and heel, complete set of wrenches to fit all nuts and bolts on engine, two monkey wrenches, one set of driving-box packing tools, one machinist's hammer, one soft hammer and three cold chisels (two flat and one cape).

Cans: One long spout quart oil can, one two gallon oil can, and one tallow pot.

Firing Irons: One poker, one scraper, one slice bar, and one scoop shovel.
Headlight.

Brake.

Couplers.

Finish. Boiler lagged with, neatly jacketed, and secured by iron bands. Dome lagged with same material as boiler, with painted iron casing on body and cast iron top and bottom rings. Cylinders lagged with same material as boiler, and neatly cased with iron, painted. Cylinder head covers of hydraulic forged steel, painted or polished. Steam chests with cast iron tops; bodies cased with iron, painted, except where piston valves are used. Hand rails of Running boards of wood with nosings of angle iron.

Painting. Engine and tender to be well painted and varnished. Lettering and numbering to be painted as specified by purchaser.

Gauges. All principal parts of engine accurately fitted to gauges and templates, and thoroughly interchangeable.

Case Hardening. All finished movable nuts and all wearing surfaces of valve motion made of steel, or iron case hardened.

Alloy. All wearing brasses made of phosphor bronze or ingot copper and tin, alloyed in proportion to give best mixture for wearing bearings.

Threads. All threads on bolts to be United States standard.

TENDER.

Tank. Tank of steel strongly put together, with angle-iron corners and well braced. Top, inside, and bottom plates thick; outside plates thick; riveted with inch rivets. inches pitch. Capacity gallons (of 231 cubic inches). Shape of tank .

Frame. Tender frame substantially built of, strongly braced.
Trucks. Two four-wheeled centre-bearing trucks; made with wrought iron side bars and cross beams of wood or channel iron; additional bearings at sides of back truck. Springs, crucible cast steel, tempered in oil.

Wheels..................inches diameter. Brakes on all wheels.

Axles of hammered steel; outside journals..................inches diameter and..................inches long. Oil tight boxes with brass bearings.

Tool Boxes. Tool-boxes of hard wood, fitted with locks and keys.
CLASS DESIGNATIONS.

The different classes of locomotives illustrated in this catalogue are designated by a combination of figures with one of the letters C, D, or E, to indicate both the plan and size, as follows:

The letter C indicates that four wheels are connected as driving-wheels.

The letter D indicates that six wheels are connected as driving-wheels.

The letter E indicates that eight wheels are connected as driving-wheels.

A figure (4, 6, 8, 10, or 12) is used as an initial figure, to indicate the whole number of wheels under the locomotive.

A figure or figures, following the initial figure, indicates the diameter of the cylinders, viz.:

8 indicates cylinders 7 inches in diameter.

10½ indicates cylinders 8 inches in diameter.

11 indicates cylinders 9 inches in diameter with stroke not exceeding 14 inches.

12 indicates cylinders 9 inches in diameter with stroke exceeding 14 inches.

14 indicates cylinders 10" dia. 34 indicates cylinders 20" dia.

16 indicates cylinders 11" dia. 36 indicates cylinders 21" dia.

18 indicates cylinders 12" dia. 38 indicates cylinders 22" dia.

20 indicates cylinders 13" dia. 40 indicates cylinders 23" dia.

22 indicates cylinders 14" dia. 42 indicates cylinders 24" dia.

24 indicates cylinders 15" dia. 44 indicates cylinders 25" dia.

26 indicates cylinders 16" dia. 46 indicates cylinders 26" dia.

28 indicates cylinders 17" dia. 48 indicates cylinders 27" dia.

30 indicates cylinders 18" dia. 50 indicates cylinders 28" dia.

32 indicates cylinders 19" dia.

Thus, 8-24 C indicates a locomotive with eight wheels in all, having four wheels coupled, and cylinders fifteen inches in diam-
eter; 8-24 D indicates a locomotive with eight wheels in all, having six wheels coupled, and cylinders of the same diameter; and 10-34 E indicates a locomotive with ten wheels in all, having eight wheels coupled, and cylinders twenty inches in diameter.

The same rule applies to Baldwin four-cylinder compound locomotives (Vauclain system). Thus, 10-4% D indicates a locomotive with ten wheels in all, having six wheels coupled, a fourteen-inch high-pressure cylinder on each side, and a twenty-four-inch low-pressure cylinder on each side.

The addition of the fraction \( \frac{1}{4} \) indicates that there is a truck placed at each end of the locomotive. Thus, 8-24\( \frac{1}{4} \) C indicates a locomotive with eight wheels in all, having four wheels coupled, cylinders fifteen inches in diameter, and a two-wheeled truck at each end.

The addition of the fraction \( \frac{1}{2} \) indicates that the front truck is omitted and a rear truck is placed back of the fire-box. Thus, 8-24 \( \frac{1}{2} \) D indicates a locomotive with eight wheels in all, having six wheels coupled, cylinders fifteen inches in diameter, and a two-wheeled rear truck.

From the above system of classification, and omitting the figures indicating the cylinder diameter for particular sizes, the following type designations are deduced:

4 C Tank. Two pairs of coupled wheels, with saddle or side tanks, no trucks.
4 C Tender. Two pairs of coupled wheels, with separate tender, no trucks.
6 C Tank. Two pairs of coupled wheels and two-wheeled front truck, with saddle or side tanks.
6 C Tender. Two pairs of coupled wheels and two-wheeled front truck, with separate tender.
6\( \frac{1}{2} \) C Tank. Two pairs of coupled wheels and two-wheeled back truck, with saddle, side, or rear tanks.
8 C Tender. American type. Two pairs of coupled wheels, four-wheeled front truck, and separate tender.
8\( \frac{1}{4} \) C Tank. Two pairs of coupled wheels, with two-wheeled truck front, and two-wheeled truck back, with saddle or side tanks.
8 1/4 C Tender. Columbia type. Two pairs of coupled wheels, two-wheeled front truck, and one pair of trailing wheels under fire box, with separate tender.

8 1/2 C Tank. Two pairs of coupled wheels, with four-wheeled back truck, supporting tank at back end.

10 1/4 C Tender. Atlantic type. Two pairs of coupled wheels, four-wheeled front truck, and one pair of trailing wheels under fire-box, with separate tender.

6 D Tank. Three pairs of coupled wheels, with saddle or side tanks, no trucks.

6 D Tender. Three pairs of coupled wheels, with separate tender, no trucks.

8 D Tender. Mogul type. Three pairs of coupled wheels, two-wheeled front truck, and separate tender.

8 1/2 D Tank. Three pairs of coupled wheels and two-wheeled back truck, with saddle, side, or rear tanks.

10 D Tender. Three pairs of coupled wheels, four-wheeled front truck, and separate tender.

10 1/4 D Tank. Three pairs of coupled wheels, two-wheeled front and two-wheeled back truck, with saddle or side tanks.

10 E Tender. Consolidation type. Four pairs of coupled wheels, two-wheeled front truck, and separate tender.

12 1/4 E Tank. Four pairs of coupled wheels, two-wheeled front and two-wheeled back truck with saddle or side tanks.

The figures following the class designation, as found on every locomotive, give the class number for that locomotive, and supply an individual designation for it, in addition to the construction number. Thus, 8-26 C 500 means the five-hundredth locomotive of the 8-26 C class.

Cuts of these, and other types, more fully illustrating this system of classification, are shown on pages 240 to 252.
**"AMERICAN" TYPE LOCOMOTIVES.**

**Gauge, 3 Feet 6 Inches, or One Metre.**

**Fuel, Bituminous Coal or Wood.**

**WEIGHT AND CAPACITY BASED ON 180 POUNDS BOILER PRESSURE.**

**DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF FOUR SIZES OF THIS PATTERN.**

**Series 908. Code Word, "Lutricole"**

<table>
<thead>
<tr>
<th>CLASS</th>
<th>Cylinders, Diam. Stroke, Inches</th>
<th>Diam. of Driving-Wheels, Inches</th>
<th>Wheel-Base, Feet</th>
<th>Capacity of Tender for Water, 8 1/2-Pound Gallons</th>
<th>Weight in Working Order, Pounds</th>
<th>LOAD in TONS (OF 2240 POUNDS) OF CARS AND LADING.</th>
<th>CODE WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>On all Driving-Wheels</td>
<td>On a Level</td>
<td>On a Grade per Mile of 28.4 Feet, 52.8 Feet, 79.2 Feet, 106.8 Feet, 132 Feet, 158.4 Feet, or 1/4 per, 1 per, or 1 1/2 per, 2 per, or 2 1/2 per, or 3 per cent.</td>
<td></td>
</tr>
<tr>
<td>8-18 C</td>
<td>12 x 18 or 20</td>
<td>48 to 56</td>
<td>21' 1 1/2&quot; 7' 6&quot;</td>
<td>1800</td>
<td>49,000</td>
<td>32,000</td>
<td>825</td>
</tr>
<tr>
<td>8-20 C</td>
<td>13 x 18 or 20</td>
<td>48 to 56</td>
<td>21' 9&quot; 7' 10&quot;</td>
<td>2000</td>
<td>57,000</td>
<td>37,000</td>
<td>975</td>
</tr>
<tr>
<td>8-22 C</td>
<td>14 x 18 or 20</td>
<td>48 to 56</td>
<td>22' 1&quot; 8' 2&quot;</td>
<td>2200</td>
<td>64,000</td>
<td>42,000</td>
<td>1120</td>
</tr>
<tr>
<td>8-24 C</td>
<td>15 x 18 or 20</td>
<td>48 to 56</td>
<td>22' 5&quot; 8' 6&quot;</td>
<td>2400</td>
<td>72,000</td>
<td>48,000</td>
<td>1280</td>
</tr>
</tbody>
</table>

This type is suitable for passenger, freight, or mixed service, where the run is of such length as to require a separate tender, or for short lines intended ultimately to be extended. It is called the "American" type because of its almost universal use for many years throughout the United States for nearly every variety of service. Heavier locomotives of the "American" type are included in Series 917, page 112.

The total wheel-base of engine, with six-wheeled tender attached, varies from 37 feet 2 inches for class 8-18 C, to 38 feet 6 inches for class 8-24 C. From 18 inches to 2 feet should be added to give the length of turn-table required.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8-18 C and 8-20 C can be used on rails of 35 to 40 pounds per yard, and classes 8-22 C and 8-24 C, 45 to 50 pounds.

For remarks on tractive power, see pages 90 to 92.
### "AMERICAN" TYPE LOCOMOTIVES.

**Gauge, 3 Feet 6 Inches, or One Metre.**

**Fuel, Bituminous Coal or Wood.**

**Weight and Capacity Based on 160 Pounds Boiler Pressure.**

**Dimensions, Weights and Tractive Power of Three Sizes of This Pattern.**

**Series 917.**

**Code Word, "Lutteur"**

<table>
<thead>
<tr>
<th>CLASS</th>
<th>Cylinders.</th>
<th>Diam. Stroke.</th>
<th>Diam. of Driving-Wheels.</th>
<th>Wheel-Base.</th>
<th>Capacity of Tender for Water.</th>
<th>Weight in Working Order.</th>
<th>Pounds.</th>
<th>Load in Tons (of 2240 Pounds) of Cars and Lading.</th>
<th>On a Grade per Mile of 28.4 Feet, 52.8 Feet, 79.2 Feet, 105.6 Feet, 132 Feet, 158.4 Feet, or ½ per cent.</th>
<th>On a Grade per Mile of 1 per cent.</th>
<th>On a Grade per Mile of 1½ per cent.</th>
<th>On a Grade per Mile of 2 per cent.</th>
<th>On a Grade per Mile of 2½ per cent.</th>
<th>On a Grade per Mile of 3 per cent.</th>
<th>Code Word.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-22 C</td>
<td>14 x 20 or 22</td>
<td>54</td>
<td>18' 2&quot;</td>
<td>6' 0&quot;</td>
<td>2200</td>
<td>64,000</td>
<td>44,000</td>
<td>1150</td>
<td>470</td>
<td>275</td>
<td>190</td>
<td>135</td>
<td>105</td>
<td>80</td>
<td>Luttons</td>
</tr>
<tr>
<td>8-24 C</td>
<td>15 x 22 or 24</td>
<td>60</td>
<td>19' 6&quot;</td>
<td>6' 6&quot;</td>
<td>2400</td>
<td>72,000</td>
<td>50,000</td>
<td>1320</td>
<td>535</td>
<td>315</td>
<td>215</td>
<td>160</td>
<td>120</td>
<td>95</td>
<td>Luttuoso</td>
</tr>
<tr>
<td>8-26 C</td>
<td>16 x 22 or 24</td>
<td>60</td>
<td>20' 4&quot;</td>
<td>7' 0&quot;</td>
<td>2600</td>
<td>80,000</td>
<td>56,000</td>
<td>1475</td>
<td>600</td>
<td>355</td>
<td>240</td>
<td>175</td>
<td>135</td>
<td>105</td>
<td>Lutulencia</td>
</tr>
</tbody>
</table>

The locomotives of Series 908 have deep fire-boxes between the driving axles, placed over depressed slab frames. In the larger classes of eight-wheel or "American" type locomotives the grate area which can be thus obtained is limited by the spread of driving-wheels practicable. To obtain increased grate area the fire-box is extended back over the rear driving-axle, and the frames are, therefore, depressed only at the front of the fire-box to give sufficient depth under the tubes. In this construction it is practicable and desirable to shorten the spread of driving-wheels. This form of fire-box is suitable for burning coal, but the deeper fire-boxes of Series 908 are preferable for wood-burning locomotives.

Assuming that steel rails, properly supported by cross ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, class 8-22 C can be used on rails of 50 pounds per yard, class 8-24 C, 55 pounds, and class 8-26 C, 60 pounds.

For remarks on tractive power, see pages 90 to 92.
"ATLANTIC" TYPE LOCOMOTIVES.

TWO PAIRS OF DRIVING-WHEELS, TWO TRAILING-WHEELS AND FOUR-WHEELED LEADING TRUCK.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF THREE SIZES OF THIS PATTERN.


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10-22½ C</td>
<td>14 x 20</td>
<td>50</td>
<td>18' 2&quot;</td>
<td>0' 2&quot;</td>
<td>4' 7&quot;</td>
<td>2600</td>
</tr>
<tr>
<td>10-24½ C</td>
<td>15 x 22</td>
<td>54</td>
<td>19' 4&quot;</td>
<td>10' 0&quot;</td>
<td>5' 0&quot;</td>
<td>2800</td>
</tr>
<tr>
<td>10-26½ C</td>
<td>16 x 22</td>
<td>54</td>
<td>19' 4&quot;</td>
<td>10' 0&quot;</td>
<td>5' 0&quot;</td>
<td>3000</td>
</tr>
</tbody>
</table>

Locomotives of this plan are especially adapted to high speed service. The driving-wheels are placed forward of the fire-box, allowing the use of a boiler of large heating surface, with a deep fire box placed over the frames, and giving a low centre of gravity with large driving-wheels. Excessive weight per axle is obviated by the introduction of a pair of trailing wheels at the rear, under the overhanging fire box. The driving-wheels are coupled closely together, affording a short parallel rod, which is an important consideration in high speed service, at the same time giving ample length of main rod. The coupled and trailing-wheels are equalized together, giving the locomotive a smooth and easy motion when running at high speed.

The total wheel-base of engine, with eight-wheeled tender attached, varies from 41 feet 6 inches for class 10-22½ C, to 43 feet for class 10-26½ C. From 18 inches to 2 feet should be added to give length of turn-table desired.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, class 10-22½ C can be used on rails of 45 pounds per yard, class 10-24½ C 50 pounds, and 10-26½ C 60 pounds.

For remarks on tractive power, see pages 90 to 92.
"MOGUL" TYPE LOCOMOTIVES.
SIX-WHEELED-CONNECTED, WITH PONY TRUCK AND SEPARATE TENDER, FOR FREIGHT, OR MIXED SERVICE.
GAUGE, 3 FEET 6 INCHES, OR ONE METRE.
FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.
DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TWELVE SIZES OF THIS PATTERN.

Series 911. Code Word, "Luurkorven"

<table>
<thead>
<tr>
<th>CLASS</th>
<th>Cylinder Diam. x Stroke, Inches</th>
<th>Diam. of Driving-Wheels, Inches</th>
<th>Wheel-Basis</th>
<th>Capacity of Tender for Water, 8%5 pound Gallons</th>
<th>Weight in Working Order, Pounds</th>
<th>LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING, On a Grade per Mile of</th>
<th>CODE WORD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
<td>Of Driving-Wheels</td>
<td>On all Driving-Wheels</td>
<td>On a Level. 28.4 Feet, 28.8 Feet, 79.2 Feet, 106.8 Feet, 122 Feet, 158.4 Feet</td>
<td></td>
</tr>
<tr>
<td>8-14 D</td>
<td>10 x 16</td>
<td>38</td>
<td>14' 1/2'' 8'' 0''</td>
<td>1400</td>
<td>30,000</td>
<td>24,000</td>
<td>675</td>
</tr>
<tr>
<td>8-16 D</td>
<td>11 x 16</td>
<td>38</td>
<td>14' 5/8'' 8'' 4/8''</td>
<td>1600</td>
<td>36,000</td>
<td>30,000</td>
<td>775</td>
</tr>
<tr>
<td>8-18 D</td>
<td>12 x 18</td>
<td>42</td>
<td>15' 2/8'' 9'' 0''</td>
<td>1800</td>
<td>44,000</td>
<td>36,000</td>
<td>950</td>
</tr>
<tr>
<td>8-20 D</td>
<td>13 x 18</td>
<td>42</td>
<td>16' 0'' 9'' 8/8''</td>
<td>2000</td>
<td>51,000</td>
<td>42,000</td>
<td>1100</td>
</tr>
<tr>
<td>8-22 D</td>
<td>14 x 18</td>
<td>42</td>
<td>16' 3/8'' 9'' 8/8''</td>
<td>2200</td>
<td>57,000</td>
<td>48,000</td>
<td>1275</td>
</tr>
<tr>
<td>8-24 D</td>
<td>15 x 18</td>
<td>42</td>
<td>18' 0'' 10'' 6/8''</td>
<td>2400</td>
<td>66,000</td>
<td>56,000</td>
<td>1500</td>
</tr>
<tr>
<td>8-26 D</td>
<td>16 x 18</td>
<td>42</td>
<td>18' 6'' 11'' 3/8''</td>
<td>2600</td>
<td>72,000</td>
<td>62,000</td>
<td>1650</td>
</tr>
<tr>
<td>8-28 D</td>
<td>17 x 20</td>
<td>48</td>
<td>18' 11'' 11'' 6/8''</td>
<td>2800</td>
<td>81,000</td>
<td>70,000</td>
<td>1875</td>
</tr>
<tr>
<td>8-30 D</td>
<td>17 x 22</td>
<td>48</td>
<td>18' 11'' 11'' 6/8''</td>
<td>3000</td>
<td>92,000</td>
<td>80,000</td>
<td>2200</td>
</tr>
</tbody>
</table>

Locomotives of this type are suitable for passenger, freight, or mixed service, where the eight-wheeled, or "American" type, would not afford sufficient power, or where the requisite weight on the driving-wheels, if carried by only two pairs, would be greater than the rails could safely bear.

The front and back driving-wheels must have flanged tires in this type of locomotive; the middle or main driving-wheels have wide tires without flanges. The "pony truck" has a swinging bolster, and by means of a radius bar is made to radiate about a point located between itself and the front driving-axle.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8-14 D to 8-20 D can be used on rails of 20 to 30 pounds per yard; classes 8-22 D and 8-24 D, 35 to 40 pounds; classes 8-26 D and 8-28 D, 45 to 50 pounds; class 8-30 D, 60 pounds.

For remarks on tractive power, see pages 90 to 92.
"TEN-WHEELED" TYPE LOCOMOTIVES.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE.   FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TEN SIZES OF THIS PATTERN.


| CLASS | Cylinders, Diam. Stroke, Inches | Wheel Base, Diam. of Driving-Wheels, Inches | Capacity of Tender for Water, 8 1/2-pound Gallons | Weight in Working Order, Pounds | LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING, On a Grade per Mile of 
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10-18 D</td>
<td>12 x 18</td>
<td>42</td>
<td>17' 7&quot;</td>
<td>9' 0&quot;</td>
<td>1800</td>
</tr>
<tr>
<td>10-20 D</td>
<td>13 x 18</td>
<td>42</td>
<td>18' 5&quot;</td>
<td>9' 0&quot;</td>
<td>2000</td>
</tr>
<tr>
<td>10-22 D</td>
<td>14 x 18</td>
<td>42</td>
<td>18' 8&quot;</td>
<td>9' 0&quot;</td>
<td>2200</td>
</tr>
<tr>
<td>10-24 D</td>
<td>15 x 18</td>
<td>42</td>
<td>19' 10&quot;</td>
<td>10' 0&quot;</td>
<td>2400</td>
</tr>
<tr>
<td>10-26 D</td>
<td>16 x 18</td>
<td>42</td>
<td>20' 4&quot;</td>
<td>11' 0&quot;</td>
<td>2600</td>
</tr>
<tr>
<td>10-28 D</td>
<td>16 x 20</td>
<td>48</td>
<td>20' 4&quot;</td>
<td>11' 0&quot;</td>
<td>2600</td>
</tr>
<tr>
<td>10-30 D</td>
<td>17 x 20</td>
<td>42</td>
<td>21' 3&quot;</td>
<td>11' 0&quot;</td>
<td>2800</td>
</tr>
<tr>
<td>10-38 D</td>
<td>17 x 22</td>
<td>48</td>
<td>21' 3&quot;</td>
<td>11' 0&quot;</td>
<td>2800</td>
</tr>
<tr>
<td>10-35 D</td>
<td>18 x 20</td>
<td>42</td>
<td>21' 9&quot;</td>
<td>12' 0&quot;</td>
<td>3000</td>
</tr>
<tr>
<td>10-30 D</td>
<td>18 x 22</td>
<td>48</td>
<td>21' 9&quot;</td>
<td>12' 0&quot;</td>
<td>3000</td>
</tr>
</tbody>
</table>

This type is suitable for passenger, freight, or mixed service, where a locomotive of the "American" type would not afford sufficient power, or where the requisite weight, if carried on only two pairs of driving-wheels, would be greater than the rails could safely bear. The greater length of an engine of this plan admits of a longer boiler, and, consequently, greater heating surface.

If the curves are of short radius, the front and rear driving-wheels are, preferably, flanged, and the truck made with swing bolster. For lines of easy curvature the middle and rear driving-wheels may be flanged and the truck made with rigid centre.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 10-18 D to 10-22 D can be used on rails of 25 to 35 pounds per yard; and classes 10-24 D and 10-26 D, 40 to 45 pounds; and classes 10-28 D and 10-30 D, 50 to 60 pounds.

For remarks on tractive power, see pages 90 to 92.

48 & 8, T x 50.

"CONSOLIDATION" TYPE LOCOMOTIVE
FOUR-COUPLED TANK LOCOMOTIVES.

Gauge, 3 Feet 6 Inches, or One Metre. Fuel, Bituminous Coal or Wood.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

FOR ALL KINDS OF SWITCHING AND SPECIAL SERVICE IN MILLS, MINES, FURNACES, PLANTATIONS, ETC.

PRINCIPAL DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF ELEVEN SIZES OF THIS PATTERN.


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4-6 C</td>
<td>6 x 12</td>
<td>24</td>
<td>3' 10&quot;</td>
<td>110</td>
<td>12,000</td>
<td>On a Level. 29.4 Feet, or 3/4 per cent. 29.8 Feet, or 3/4 per cent. 29.2 Feet, or 3/4 per cent. 106.6 Feet, or 3/4 per cent. 132 Feet, or 3/4 per cent. 158.4 Feet, or 3/4 per cent.</td>
<td>Luxuriavias</td>
</tr>
<tr>
<td>4-8 C</td>
<td>7 x 12</td>
<td>26</td>
<td>3' 10&quot;</td>
<td>150</td>
<td>14,000</td>
<td>275</td>
<td>Luxuries</td>
</tr>
<tr>
<td>4-10½ C</td>
<td>8 x 12</td>
<td>28</td>
<td>4' 0&quot;</td>
<td>200</td>
<td>17,000</td>
<td>350</td>
<td>Luxurieux</td>
</tr>
<tr>
<td>4-11 C</td>
<td>9 x 14</td>
<td>30</td>
<td>4' 0&quot;</td>
<td>300</td>
<td>21,000</td>
<td>430</td>
<td>Luxuriosis</td>
</tr>
<tr>
<td>4-12 C</td>
<td>9 x 16</td>
<td>33</td>
<td>5' 0&quot;</td>
<td>350</td>
<td>28,000</td>
<td>500</td>
<td>Luxurouso</td>
</tr>
<tr>
<td>4-14 C</td>
<td>10 x 16</td>
<td>33</td>
<td>5' 0&quot;</td>
<td>400</td>
<td>31,000</td>
<td>650</td>
<td>Luxuristor</td>
</tr>
<tr>
<td>4-16 C</td>
<td>11 x 16</td>
<td>33 to 38</td>
<td>5' 6&quot;</td>
<td>450</td>
<td>36,000</td>
<td>775</td>
<td>Luxurists</td>
</tr>
<tr>
<td>4-18 C</td>
<td>12 x 16</td>
<td>33 to 38</td>
<td>5' 6&quot;</td>
<td>500</td>
<td>40,000</td>
<td>850</td>
<td>Luxury</td>
</tr>
<tr>
<td>4-20 C</td>
<td>13 x 18</td>
<td>35 to 42</td>
<td>6' 0&quot;</td>
<td>550</td>
<td>47,000</td>
<td>980</td>
<td>Luxus</td>
</tr>
<tr>
<td>4-22 C</td>
<td>14 x 18</td>
<td>38 to 42</td>
<td>6' 0&quot;</td>
<td>600</td>
<td>54,000</td>
<td>1175</td>
<td>Luzitosa</td>
</tr>
<tr>
<td>4-24 C</td>
<td>15 x 20</td>
<td>42 to 48</td>
<td>7' 0&quot;</td>
<td>700</td>
<td>62,000</td>
<td>1375</td>
<td>Luzbel</td>
</tr>
</tbody>
</table>

The weight given in each case is for the locomotive in working order with the tank full of water, but includes no fuel. The latter may be offset against the reduction of weight as the water is drawn from the tank. The figures given may therefore be considered as the average weight in running order.

This type of locomotive is the simplest for service on short lines, where a sufficient supply of fuel and water can be carried on the engine. All the weight, being on the driving-wheels, is utilized for adhesion, and the maximum load consistent with the weight of the engine can be drawn. Having but two pairs of wheels allows of a wheel-base short enough to pass the sharpest curves without difficulty. Engines of this type can be run equally well in either direction.

Assuming that steel rails, properly supported by cross ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 4.6 C and 4.8 C can be used on rails of 12 to 16 pounds per yard; classes 4.10½ C and 4.11 C, 20 to 25 pounds; classes 4.12 C to 4.16 C, 30 to 40 pounds; classes 4.18 C and 4.20 C, 45 to 60 pounds. If practicable, however, it is desirable to have rails heavy enough to give a greater factor of strength.

For remarks on tractive power, see pages 90 to 92.

46 & 8, ½ T. C.
FOUR-COUPLED TANK LOCOMOTIVE.
TANK LOCOMOTIVES.
WITH TWO PAIRS OF DRIVING-WHEELS AND TWO-WHEELED REAR TRUCK.
GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.
WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.
DIMENSIONS, WEIGHS AND TRACTIVE POWER OF NINE SIZES OF THIS PATTERN.
Series 903. Code Word, "Luzeluze".

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>短轴</td>
<td>8 x 12</td>
<td>28</td>
<td>9' 7'</td>
<td>3' 9'</td>
<td>300</td>
<td>23,000</td>
</tr>
<tr>
<td>短轴</td>
<td>9 x 14</td>
<td>33</td>
<td>10' 0'</td>
<td>3' 6'</td>
<td>350</td>
<td>28,000</td>
</tr>
<tr>
<td>短轴</td>
<td>9 x 16</td>
<td>33</td>
<td>10' 6'</td>
<td>4' 6'</td>
<td>400</td>
<td>32,000</td>
</tr>
<tr>
<td>短轴</td>
<td>10 x 16</td>
<td>37</td>
<td>11' 8'</td>
<td>5' 0'</td>
<td>450</td>
<td>35,000</td>
</tr>
<tr>
<td>短轴</td>
<td>10 x 14</td>
<td>37</td>
<td>12' 0'</td>
<td>5' 0'</td>
<td>500</td>
<td>40,000</td>
</tr>
<tr>
<td>短轴</td>
<td>12 x 16</td>
<td>42</td>
<td>13' 3'</td>
<td>6' 0'</td>
<td>600</td>
<td>47,000</td>
</tr>
<tr>
<td>短轴</td>
<td>13 x 18</td>
<td>42</td>
<td>14' 1'</td>
<td>6' 6'</td>
<td>700</td>
<td>54,000</td>
</tr>
<tr>
<td>短轴</td>
<td>14 x 20</td>
<td>48</td>
<td>15' 0'</td>
<td>6' 6'</td>
<td>800</td>
<td>62,000</td>
</tr>
<tr>
<td>短轴</td>
<td>15 x 20</td>
<td>48</td>
<td>15' 4'</td>
<td>6' 6'</td>
<td>900</td>
<td>70,000</td>
</tr>
</tbody>
</table>

The driving-wheels of this type are equalized together, the truck is centre-bearing, with swinging bolster and radius bar. For operating short lines, where a limited supply of water and fuel is sufficient, this plan of locomotive has the following advantages:

Having six wheels it is steady, rides smoothly, without plunging, and causes little wear of track.
The fuel is carried on the engine frames at the back. The water supply is carried in a saddle-tank on the boiler or in side-tanks on each side of the boiler. The weight of the water adds to the adhesion and increases the hauling capacity.
The weight is well distributed: the principal portion is carried on equalizing levers between the driving-wheels. This affords an equal distribution on the four driving-wheels. The pony truck carries the weight of the fuel, with part of the weight of the overhanging fire-box.
The engine can be run either way without turning, and will readily traverse curves of short radius. As the weight is carried on the two side equalizers between the driving-wheels and the centre-pin of the pony truck, every wheel finds a bearing on level or uneven track.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 6-10½ C and 6-14½ C can be used on rails of 80 to 95 pounds per yard; classes 6-12½ C and 6-14½ C, 30 to 35 pounds; 6-10½ C and 6-14½ C, 40 to 45 pounds 6-20½ C and 6-24½ C, 50 to 60 pounds; and 6-24½ C, 65 to 70 pounds.

For remarks on tractive power, see pages 90 to 92.

1½ & 8½ T. C.
FOUR-COUPLED TANK LOCOMOTIVE WITH TWO-WHEELED REAR TRUCK.
"FORNEY" TYPE LOCOMOTIVES.

WITH TWO PAIRS OF DRIVING-WHEELS AND FOUR-WHEELED REAR TRUCK.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TEN SIZES OF THIS PATTERN.

Series 904. Code Word, "Lyncestae."

<table>
<thead>
<tr>
<th>CLASS</th>
<th>Cylinders, Diam. Stroke, Inches</th>
<th>Diam. of Driving-Wheels, Inches</th>
<th>Wheel-Base, Of Driving-Wheels, Total</th>
<th>Capacity of Tank for Water, 8 1/2-Pound Gallons</th>
<th>Weight in Working Order, Pounds</th>
<th>LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>On a Level, 26.4 Feet, or 1/2 per cent.</td>
</tr>
<tr>
<td>8-10 1/2 C</td>
<td>8 x 12</td>
<td>28</td>
<td>12' 9&quot; 3' 9&quot;</td>
<td>400</td>
<td>400</td>
<td>175</td>
</tr>
<tr>
<td>8-11 1/2 C</td>
<td>9 x 14</td>
<td>33</td>
<td>13' 0&quot; 4' 0&quot;</td>
<td>500</td>
<td>500</td>
<td>220</td>
</tr>
<tr>
<td>8-12 1/2 C</td>
<td>9 x 16</td>
<td>33</td>
<td>13' 0&quot; 4' 6&quot;</td>
<td>600</td>
<td>600</td>
<td>250</td>
</tr>
<tr>
<td>8-14 1/2 C</td>
<td>10 x 16</td>
<td>37</td>
<td>15' 11&quot; 5' 0&quot;</td>
<td>700</td>
<td>700</td>
<td>400</td>
</tr>
<tr>
<td>8-16 1/2 C</td>
<td>11 x 16</td>
<td>37</td>
<td>16' 3&quot; 5' 0&quot;</td>
<td>800</td>
<td>800</td>
<td>535</td>
</tr>
<tr>
<td>8-18 1/2 C</td>
<td>12 x 18</td>
<td>42</td>
<td>17' 9&quot; 5' 8&quot;</td>
<td>900</td>
<td>900</td>
<td>610</td>
</tr>
<tr>
<td>8-20 1/2 C</td>
<td>13 x 18</td>
<td>42</td>
<td>18' 8&quot; 6' 0&quot;</td>
<td>1000</td>
<td>1000</td>
<td>680</td>
</tr>
<tr>
<td>8-22 1/2 C</td>
<td>14 x 20</td>
<td>42</td>
<td>19' 2&quot; 6' 6&quot;</td>
<td>1100</td>
<td>1100</td>
<td>855</td>
</tr>
<tr>
<td>8-24 1/2 C</td>
<td>15 x 20</td>
<td>48</td>
<td>20' 7&quot; 6' 6&quot;</td>
<td>1200</td>
<td>1200</td>
<td>1350</td>
</tr>
<tr>
<td>8-26 1/2 C</td>
<td>16 x 20</td>
<td>48</td>
<td>22' 0&quot; 7' 10&quot;</td>
<td>1300</td>
<td>1300</td>
<td>1650</td>
</tr>
</tbody>
</table>

Locomotives of this type are compact and powerful for their aggregate weight, and are suitable for suburban passenger traffic, elevated railways, plantation and other service where the run is not long enough to necessitate a separate tender. As the whole weight of the boiler rests on the driving-wheels, the adhesion is ample and the starting power great. They are designed to run either forward or backward, but the wear on driving-wheel flanges is least when running with truck ahead. The driving-wheels are equalized together; the truck is centre-bearing and has a swinging bolster. Locomotives of this plan readily traverse curves of short radius; on the elevated lines in New York and Chicago 4' 8 1/2" gauge locomotives of this type are used on curves of 90 feet radius on the main line. As the weight is carried on two side equalizers between the driving-wheels and the centrepin of the truck, each wheel finds a bearing, notwithstanding any unevenness of the track. The engine, therefore, rides as smoothly as an eight-wheeled or American type locomotive.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8-10 1/2 C and 8-11 1/2 C may be used on rails of 20 to 25 pounds per yard; classes 8-12 1/2 C to 8-16 1/2 C, 30 to 35 pounds; classes 8-18 1/2 C and 8-20 1/2 C, 40 to 50 pounds; classes 8-22 1/2 C to 8-26 1/2 C, 55 to 70 pounds.

For remarks on tractive power, see pages 90 to 92.
“FORNEY” TYPE LOCOMOTIVE, WITH FOUR-WHEELED REAR TRUCK
FOUR COUPLED LOCOMOTIVES.

WITH TWO-WHEELED LEADING TRUCK AND SEPARATE TENDER FOR LOCAL PASSENGER, SWITCHING, LOGGING, PLANTATION AND SPECIAL SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF NINE SIZES OF THIS PATTERN.

Series 901. Code Word, "Lynxooogen"
FOUR-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVES.
WITH TWO-WHEELED LEADING AND TRAILING TRUCKS.

GAUGE, 3 Feet 6 Inches, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF NINE SIZES OF THIS PATTERN.

Series 905. Code Word, "LYRICAL."

<table>
<thead>
<tr>
<th>Class</th>
<th>Cylinders, Diam. Stroke, Inches</th>
<th>Diam. of Driving-Wheels, Inches</th>
<th>Wheel-Base, Total</th>
<th>Capacity of Tank for Water, 833-Pound Gallons</th>
<th>Weight in Working Order, Pounds</th>
<th>On a Grade per Mile of</th>
<th>Load in Tons (of 2240 Pounds of Cars and Lading)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-10</td>
<td>8 x 12</td>
<td>33 to 37</td>
<td>15' 0&quot; 4' 2&quot;</td>
<td>350</td>
<td>26,000</td>
<td>15,000</td>
<td>325 140 85 60 40 30 25</td>
</tr>
<tr>
<td>8-11</td>
<td>9 x 14</td>
<td>33 to 37</td>
<td>15' 7&quot; 4' 0&quot;</td>
<td>400</td>
<td>32,000</td>
<td>19,000</td>
<td>425 185 110 75 45 35</td>
</tr>
<tr>
<td>8-12</td>
<td>9 x 16</td>
<td>37 to 41</td>
<td>15' 10&quot; 4' 6&quot;</td>
<td>450</td>
<td>35,000</td>
<td>22,000</td>
<td>500 205 125 85 55 40</td>
</tr>
<tr>
<td>8-14</td>
<td>10 x 16</td>
<td>37 to 41</td>
<td>17' 8&quot; 5' 0&quot;</td>
<td>500</td>
<td>40,000</td>
<td>26,000</td>
<td>600 250 150 105 75 50</td>
</tr>
<tr>
<td>8-16</td>
<td>11 x 16</td>
<td>37 to 41</td>
<td>18' 0&quot; 5' 0&quot;</td>
<td>600</td>
<td>46,000</td>
<td>30,000</td>
<td>725 305 185 130 95 75</td>
</tr>
<tr>
<td>8-18</td>
<td>12 x 18</td>
<td>41 to 41</td>
<td>19' 7&quot; 5' 8&quot;</td>
<td>700</td>
<td>58,000</td>
<td>38,000</td>
<td>925 385 230 160 120 95 75</td>
</tr>
<tr>
<td>8-20</td>
<td>13 x 18</td>
<td>41 to 45</td>
<td>20' 8&quot; 6' 0&quot;</td>
<td>800</td>
<td>66,000</td>
<td>44,000</td>
<td>1050 440 265 185 140 110 85</td>
</tr>
<tr>
<td>8-22</td>
<td>14 x 20</td>
<td>45 to 48</td>
<td>22' 0&quot; 6' 6&quot;</td>
<td>900</td>
<td>76,000</td>
<td>52,000</td>
<td>1275 530 320 225 170 130 105</td>
</tr>
<tr>
<td>8-24</td>
<td>15 x 20</td>
<td>48</td>
<td>22' 6&quot; 6' 6&quot;</td>
<td>1000</td>
<td>84,000</td>
<td>58,000</td>
<td>1450 590 360 250 190 150 120</td>
</tr>
</tbody>
</table>

This type of engine is suitable for suburban passenger, switching and logging service, where it is desirable to run forward and backward with turning, and where the run is not long enough to need a separate tender. The front truck is centre-bearing and is equalized with the forward driving-wheels. The rear truck is side-bearing and is equalized with the rear driving-wheels. The back of the engine is thus carried on two side bearings at the fulcroms.

The engine will, therefore, ride smoothly, and all the wheels find a bearing on the most uneven track. Each track has a swinging bolster and radius-bar and protects the flanges of the driving-wheels when curving. The short rigid wheel-base of this plan, in proportion to its total wheel-base and power, enables it to traverse curves of short radius.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 8-10 X C and 8-11 X C can be used on rails of 15 to 20 pounds per yard; classes 8-12 X C to 8-16 X C, 25 to 35 pounds; classes 8-18 X C and 8-20 X C, 40 to 45 pounds; classes 8-22 X C and 8-24 X C, 50 to 60 pounds.

For remarks on tractive power, see pages 90 to 92.
SIX-COUPLED TANK LOCOMOTIVES, WITH TWO-WHEELED REAR TRUCK.

FOR PLANTATION, LOGGING, OR SPECIAL SERVICE.

GAUGE, 3 FEET 6 INCHES, OR ONE METRE. FUEL, BITUMINOUS COAL OR WOOD.

WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.

DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF ELEVEN SIZES OF THIS PATTERN.

**Series 916. Code Word, "Lyriker."**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total of Driving-Wheels</td>
<td>Tank on Boiler.</td>
<td>On all Driving-Wheels.</td>
<td>On a Grade per Mile of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total.</td>
<td>Weight.</td>
<td>On a Level</td>
<td>26.4 Feet</td>
</tr>
<tr>
<td>8-10 ½ D</td>
<td>8 x 12</td>
<td>28</td>
<td>11½ 3½ 5½ 5½</td>
<td>350</td>
<td>23,000</td>
<td>19,000</td>
<td>175</td>
</tr>
<tr>
<td>8-11 ½ D</td>
<td>9 x 14</td>
<td>33</td>
<td>12½ 9½ 6½ 6½</td>
<td>400</td>
<td>28,000</td>
<td>24,000</td>
<td>235</td>
</tr>
<tr>
<td>8-12 ½ D</td>
<td>9 x 16</td>
<td>33</td>
<td>13½ 4½ 7½ 4½</td>
<td>450</td>
<td>30,500</td>
<td>26,000</td>
<td>255</td>
</tr>
<tr>
<td>8-14 ½ D</td>
<td>10 x 16</td>
<td>38</td>
<td>14½ 2½ 7½ 6½</td>
<td>500</td>
<td>34,000</td>
<td>20,000</td>
<td>275</td>
</tr>
<tr>
<td>8-16 ½ D</td>
<td>11 x 16</td>
<td>38</td>
<td>15½ 9½ 7½ 9½</td>
<td>550</td>
<td>38,000</td>
<td>36,000</td>
<td>285</td>
</tr>
<tr>
<td>8-18 ½ D</td>
<td>12 x 18</td>
<td>44</td>
<td>16½ 3½ 8½ 8½</td>
<td>600</td>
<td>42,000</td>
<td>41,000</td>
<td>300</td>
</tr>
<tr>
<td>8-20 ½ D</td>
<td>13 x 18</td>
<td>44</td>
<td>17½ 1½ 9½ 0½</td>
<td>700</td>
<td>48,000</td>
<td>48,000</td>
<td>325</td>
</tr>
<tr>
<td>8-22 ½ D</td>
<td>14 x 20</td>
<td>48</td>
<td>18½ 1½ 9½ 5½</td>
<td>800</td>
<td>52,000</td>
<td>52,000</td>
<td>350</td>
</tr>
<tr>
<td>8-24 ½ D</td>
<td>15 x 20</td>
<td>48</td>
<td>19½ 5½ 9½ 9½</td>
<td>900</td>
<td>56,000</td>
<td>56,000</td>
<td>365</td>
</tr>
<tr>
<td>8-26 ½ D</td>
<td>16 x 22</td>
<td>48</td>
<td>20½ 3½ 10½ 10½</td>
<td>1000</td>
<td>60,000</td>
<td>60,000</td>
<td>385</td>
</tr>
</tbody>
</table>

Locomotives of this plan are suitable for plantation, logging, or special service, where the runs are not long enough to require a separate tender. The addition of a truck avoids the plunging or galloping motion to which a four-wheeled or six-wheeled tank locomotive is subject when used at more than a moderate speed. The increased space back of the cab also permits of greater coal space and more room for the enginemen than is practicable without the truck. The three pairs of driving wheels are equalized together; the truck is centre bearing, and has a swinging bolster and radius bar.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, Classes 8-10½ D to 8-14½ D can be used on rails of 20 to 25 pounds per yard; Classes 8-16½ D and 8-18½ D, 30 to 35 pounds; Classes 8-20½ D and 8-22½ D, 40 to 45 pounds; Class 8-24½ D, 50 pounds, and Class 8-26½ D, 60 pounds.

For remarks on tractive power, see pages 90 to 92.

7½ & 8½ T. C.
SIX-COUPLED TANK LOCOMOTIVE, WITH TWO WHEELED REAR TRUCK
**SIX-COUPLED “DOUBLE-ENDER” TANK LOCOMOTIVES.**

**WITH TWO-WHEELED LEADING AND TRAILING TRUCKS,**

**FOR SUBURBAN PASSENGER AND LOCAL FREIGHT SERVICE.**

**Gauge, 3 Feet 6 Inches, or One Metre.**

**Fuel, Bituminous Coal or Wood.**

**Weight and Capacity Based on 160 Pounds Boiler Pressure.**

**Dimensions, Weights and Tractive Power of Nine Sizes of this Pattern.**

**Series 912. Code Word, “Lyrodie.”**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10-16</td>
<td>D 11 x 16</td>
<td>38</td>
<td>19' 6&quot;</td>
<td>8' 8&quot;</td>
<td>550</td>
<td>48,000</td>
<td>34,000</td>
</tr>
<tr>
<td>10-18</td>
<td>D 12 x 18</td>
<td>44</td>
<td>20' 8&quot;</td>
<td>9' 6&quot;</td>
<td>650</td>
<td>54,000</td>
<td>40,000</td>
</tr>
<tr>
<td>10-20</td>
<td>D 13 x 18</td>
<td>44</td>
<td>21' 3&quot;</td>
<td>9' 4&quot;</td>
<td>700</td>
<td>62,000</td>
<td>46,000</td>
</tr>
<tr>
<td>10-22</td>
<td>D 14 x 20</td>
<td>48</td>
<td>22' 5&quot;</td>
<td>9' 8&quot;</td>
<td>850</td>
<td>75,000</td>
<td>56,000</td>
</tr>
<tr>
<td>10-24</td>
<td>D 15 x 20</td>
<td>48</td>
<td>22' 2&quot;</td>
<td>9' 9&quot;</td>
<td>900</td>
<td>80,000</td>
<td>60,000</td>
</tr>
<tr>
<td>10-24</td>
<td>D 15 x 22</td>
<td>48</td>
<td>23' 3&quot;</td>
<td>10' 0&quot;</td>
<td>1000</td>
<td>88,000</td>
<td>66,000</td>
</tr>
<tr>
<td>10-26</td>
<td>D 16 x 22</td>
<td>48</td>
<td>24' 6&quot;</td>
<td>11' 0&quot;</td>
<td>1100</td>
<td>96,000</td>
<td>72,000</td>
</tr>
<tr>
<td>10-28</td>
<td>D 17 x 22</td>
<td>48</td>
<td>24' 10&quot;</td>
<td>11' 0&quot;</td>
<td>1200</td>
<td>104,000</td>
<td>80,000</td>
</tr>
<tr>
<td>10-30</td>
<td>D 18 x 22</td>
<td>48</td>
<td>26' 0&quot;</td>
<td>12' 0&quot;</td>
<td>1300</td>
<td>114,000</td>
<td>90,000</td>
</tr>
</tbody>
</table>

This plan is suitable for suburban passenger or local freight service, where it is desirable to run forward or backward without turning, and where an engine with only two pairs of driving-wheels, but otherwise of the same design, wouldn't adapt for adequate adhesion, or where the required weight, if carried by only two pairs of driving-wheels, would be greater than the rails could safely bear. It has the following advantages:

The forward truck is equalized with the forward pair of driving-wheels, and the middle and rear pairs of driving-wheels are equalized with the rear truck. The front truck is centre bearing; the trailing truck is side-bearing. Each truck has a swinging bolster and radius bar. This arrangement enables the engine to ride smoothly and find a bearing on the most uneven track. The truck guides the engine around curves and relieves the flanges of the driving-wheels of excessive friction.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 10-16(1/2) D and 10-18(1/2) D can be used on rails of 25 to 30 pounds per yard; classes 10-20(1/2) D and 10-22(1/2) D, 35 to 40 pounds; classes 10-24(1/2) D to 10-26(1/2) D, 45 to 55 pounds; classes 10-28(1/2) D and 10-30(1/2) D, 60 to 70 pounds.

For remarks on tractive power, see pages 90 to 92.
EIGHT-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVES.
WITH TWO-WHEELED LEADING AND TRAILING TRUCKS, FOR LOCAL FREIGHT SERVICE.
GAUGE, 3 FEET 6 INCHES, OR ONE METRE.
FUEL, BITUMINOUS COAL OR WOOD.
WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.
DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF FIVE SIZES OF THIS PATTERN.

**Series 915. Code Word, "Lysiacorum."**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tank on Boiler.</td>
<td>On all Driving-Wheels.</td>
<td>On a Level, 26.4 Feet, or ½ per cent.</td>
<td>On a Grade per Mile of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total.</td>
<td>52.8 Feet, or 1 per cent.</td>
<td>79.2 Foot, or 1 ½ per cent.</td>
<td>105.6 Foot, or 2 per cent. 125 Foot, or 2 ½ per cent. 155.4 Foot, or 3 per cent.</td>
</tr>
<tr>
<td>12-26½ E</td>
<td>16 x 20</td>
<td>42</td>
<td>25' 0&quot; 12' 3&quot;</td>
<td>1100</td>
<td>98,000</td>
<td>76,000</td>
<td>1800</td>
<td>749</td>
</tr>
<tr>
<td>12-28½ E</td>
<td>17 x 20</td>
<td>42</td>
<td>26' 0&quot; 12' 6&quot;</td>
<td>1300</td>
<td>106,000</td>
<td>83,000</td>
<td>1975</td>
<td>810</td>
</tr>
<tr>
<td>12-30½ E</td>
<td>18 x 20</td>
<td>42</td>
<td>27' 8&quot; 13' 2&quot;</td>
<td>1300</td>
<td>117,000</td>
<td>91,000</td>
<td>2150</td>
<td>890</td>
</tr>
<tr>
<td>12-32½ E</td>
<td>19 x 22</td>
<td>48</td>
<td>29' 0&quot; 13'10&quot;</td>
<td>1400</td>
<td>127,000</td>
<td>98,000</td>
<td>2325</td>
<td>955</td>
</tr>
<tr>
<td>12-34½ E</td>
<td>20 x 22</td>
<td>48</td>
<td>30' 6&quot; 14' 6&quot;</td>
<td>1500</td>
<td>139,000</td>
<td>106,000</td>
<td>2500</td>
<td>1030</td>
</tr>
</tbody>
</table>

This type is suitable for local freight service, where it is desirable to run forward or backward without turning, and where an engine with only three pairs of driving-wheels, but otherwise of the same design, would not afford adequate adhesion, or, where the required weight, if carried by only three pairs of driving-wheels, would be greater than the rails could safely bear. It has the following advantages:

The forward truck is equalized with the two forward pairs of driving-wheels, and the rear truck is equalized with the two rear pairs of driving-wheels. The front truck is centre-bearing; the trailing truck is side-bearing. Each truck has a swaying bolster and radius bar. This arrangement enables the engine to ride smoothly and find a bearing on the most uneven track. The trucks guide the engine around curves and relieve the flanges of the driving-wheels of excessive friction.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 12-26½ E and 12-28½ E can be used on rails of 45 to 50 pounds per yard; and classes 12-30½ E to 12-34½ E, 55 to 65 pounds.

For remarks on tractive power, see pages 90 to 92.
EIGHT-COUPLED "DOUBLE-ENDER" TANK LOCOMOTIVE.
SIX-COUPLED SWITCHING LOCOMOTIVES.
TWO SIDE-TANKS OR SADDLE-TANK ON BOILER, FOR SWITCHING, LOGGING AND PLANTATION SERVICE.
GAUGE, 3 FEET 6 INCHES, OR ONE METRE.
FUEL, BITUMINOUS COAL OR WOOD.
WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.
DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF ELEVEN SIZES OF THIS PATTERN


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6-8 D</td>
<td>7 x 10</td>
<td>22</td>
<td>4' 10 1/2''</td>
<td>200</td>
<td>14,000</td>
</tr>
<tr>
<td>6-10 D</td>
<td>8 x 12</td>
<td>28</td>
<td>5' 5 1/2''</td>
<td>250</td>
<td>18,000</td>
</tr>
<tr>
<td>6-11 D</td>
<td>9 x 14</td>
<td>30</td>
<td>6' 3 1/2''</td>
<td>300</td>
<td>24,000</td>
</tr>
<tr>
<td>6-12 D</td>
<td>9 x 16</td>
<td>33</td>
<td>6' 11 1/2''</td>
<td>350</td>
<td>26,000</td>
</tr>
<tr>
<td>6-14 D</td>
<td>10 x 16</td>
<td>33</td>
<td>7' 6 1/2''</td>
<td>400</td>
<td>31,000</td>
</tr>
<tr>
<td>6-16 D</td>
<td>11 x 16</td>
<td>33 to 38</td>
<td>8' 6 1/2''</td>
<td>450</td>
<td>36,000</td>
</tr>
<tr>
<td>6-18 D</td>
<td>12 x 18</td>
<td>38 to 42</td>
<td>9' 6 1/2''</td>
<td>500</td>
<td>42,000</td>
</tr>
<tr>
<td>6-20 D</td>
<td>13 x 20</td>
<td>38 to 42</td>
<td>10' 6 1/2''</td>
<td>600</td>
<td>51,000</td>
</tr>
<tr>
<td>6-22 D</td>
<td>14 x 20</td>
<td>38 to 42</td>
<td>10' 6 1/2''</td>
<td>700</td>
<td>58,000</td>
</tr>
<tr>
<td>6-24 D</td>
<td>15 x 22</td>
<td>42 to 48</td>
<td>11' 1 1/2''</td>
<td>800</td>
<td>68,000</td>
</tr>
<tr>
<td>6-26 D</td>
<td>16 x 22</td>
<td>42 to 48</td>
<td>11' 1 1/2''</td>
<td>1000</td>
<td>78,000</td>
</tr>
</tbody>
</table>

LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.

<table>
<thead>
<tr>
<th>On a Level.</th>
<th>20.4 Feet, or 3¾ per cent.</th>
<th>52.8 Feet, or 1 per cent.</th>
<th>79.2 Feet, or 1 3/4 per cent.</th>
<th>106.6 Feet, or 2 per cent.</th>
<th>133 Feet, or 2 3/4 per cent.</th>
<th>158.4 Feet, or 3 per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>325</td>
<td>145</td>
<td>85</td>
<td>60</td>
<td>45</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>425</td>
<td>180</td>
<td>110</td>
<td>75</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>600</td>
<td>250</td>
<td>150</td>
<td>105</td>
<td>80</td>
<td>65</td>
<td>50</td>
</tr>
<tr>
<td>650</td>
<td>270</td>
<td>165</td>
<td>115</td>
<td>90</td>
<td>70</td>
<td>55</td>
</tr>
<tr>
<td>750</td>
<td>315</td>
<td>190</td>
<td>135</td>
<td>105</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>825</td>
<td>350</td>
<td>215</td>
<td>150</td>
<td>115</td>
<td>90</td>
<td>75</td>
</tr>
<tr>
<td>1025</td>
<td>430</td>
<td>260</td>
<td>185</td>
<td>140</td>
<td>115</td>
<td>90</td>
</tr>
<tr>
<td>1300</td>
<td>540</td>
<td>330</td>
<td>235</td>
<td>175</td>
<td>140</td>
<td>115</td>
</tr>
<tr>
<td>1500</td>
<td>610</td>
<td>375</td>
<td>265</td>
<td>200</td>
<td>160</td>
<td>130</td>
</tr>
<tr>
<td>1700</td>
<td>710</td>
<td>435</td>
<td>310</td>
<td>235</td>
<td>190</td>
<td>155</td>
</tr>
<tr>
<td>1900</td>
<td>800</td>
<td>490</td>
<td>350</td>
<td>265</td>
<td>215</td>
<td>175</td>
</tr>
</tbody>
</table>

This type is suitable for switching, logging, or plantation service, where short runs render a tender unnecessary, or, where the weight of the engine, if carried on only two pairs of wheels, would be greater than the rails could bear.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 6-8 D and 6-10 D can be used on rails of 10 to 12 pounds per yard; classes 6-11 D and 6-12 D, 15 to 20 pounds; classes 6-14 D to 6-18 D, 25 to 30 pounds; 6-20 D and 6-22 D, 35 to 45 pounds; 6-24 D and 6-26 D, 50 to 55 pounds. If practicable, however, it is desirable to have rails heavy enough to give a greater factor of strength.

For remarks on tractive power, see pages 90 to 92.

25 & 4, 24 T. C.
SIX-COUPLED LOCOMOTIVES, WITH SEPARATE TENDERS,  
FOR SWITCHING, LOGGING, AND PLANTATION SERVICE.  
Gauge, 3 Feet 6 Inches, or One Metre.  
FUEL, Bituminous Coal or Wood.  
WEIGHT AND CAPACITY BASED ON 160 POUNDS BOILER PRESSURE.  
DIMENSIONS, WEIGHTS AND TRACTIVE POWER OF TEN SIZES OF THIS PATTERN.  


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>On a Level.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>On a Grade per Mile of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4, 36.4, 36.4, 72.8, 72.8, 105.6, 132.8, 158.4.</td>
</tr>
<tr>
<td>6-8 D</td>
<td>7 x 10</td>
<td>22</td>
<td>4' 10''</td>
<td>400</td>
<td>12,000</td>
<td>300 130 80 55 40 30 25</td>
</tr>
<tr>
<td>6-10 D</td>
<td>8 x 12</td>
<td>28</td>
<td>5' 5''</td>
<td>500</td>
<td>16,000</td>
<td>400 175 105 75 55 45 35</td>
</tr>
<tr>
<td>6-11 D</td>
<td>9 x 14</td>
<td>30</td>
<td>6' 3''</td>
<td>550</td>
<td>21,000</td>
<td>550 230 140 95 75 55 45</td>
</tr>
<tr>
<td>6-12 D</td>
<td>9 x 16</td>
<td>33</td>
<td>6' 11''</td>
<td>600</td>
<td>23,000</td>
<td>600 255 155 105 80 65 50</td>
</tr>
<tr>
<td>6-14 D</td>
<td>10 x 16</td>
<td>33</td>
<td>7' 6''</td>
<td>700</td>
<td>27,000</td>
<td>700 295 180 125 95 75 60</td>
</tr>
<tr>
<td>6-16 D</td>
<td>11 x 16</td>
<td>33 to 38</td>
<td>8' 8''</td>
<td>800</td>
<td>31,000</td>
<td>800 340 205 135 105 85 65</td>
</tr>
<tr>
<td>6-18 D</td>
<td>12 x 18</td>
<td>38 to 42</td>
<td>8' 6''</td>
<td>900</td>
<td>37,000</td>
<td>975 345 244 170 130 100 80</td>
</tr>
<tr>
<td>6-20 D</td>
<td>13 x 20</td>
<td>38 to 42</td>
<td>9' 0''</td>
<td>1000</td>
<td>45,000</td>
<td>1200 495 300 210 155 125 100</td>
</tr>
<tr>
<td>6-22 D</td>
<td>14 x 20</td>
<td>38 to 42</td>
<td>10' 0''</td>
<td>1500</td>
<td>62,000</td>
<td>1500 575 345 245 185 145 115</td>
</tr>
<tr>
<td>6-24 D</td>
<td>15 x 22</td>
<td>42 to 48</td>
<td>10' 6''</td>
<td>1600</td>
<td>60,000</td>
<td>1600 665 400 250 210 170 135</td>
</tr>
</tbody>
</table>

This type is suitable for switching, logging, plantation, or mixed service. It is especially suitable where the conditions make it advisable to distribute the weight over more than two pairs of driving-wheels. In the heavier classes of narrow-gauge switching engines, the six-wheeled type, with tender, is preferable, to avoid raising the centre of gravity. The separate tender is somewhat more convenient, and, as it affords a greater supply of fuel and water than a tank engine, longer runs are permissible. The water capacity of the tender mentioned for the respective classes is generally found sufficient, but it can be varied to suit special requirements.

Assuming that steel rails, properly supported by cross-ties, can sustain, as a maximum, a weight per wheel of 2240 pounds for each ten pounds weight per yard of rail, classes 6-8 D and 6-10 D can be used on rails of 10 to 12 pounds per yard; classes 6-11 D to 6-14 D, 15 to 20 pounds; classes 6-16 D to 6-20 D, 25 to 35 pounds; classes 6-22 D and 6-24 D, 40 to 45 pounds.

For remarks on tractive power, see pages 90 to 92.

Lysipome  
Lysippe  
Lysippus  
Lysippe  
Lysianthes  
Lysiodine  
Lysiodine  
Lysiumine  
Lysiumine  
Lysiumine

\[\text{b & s t. x sq.}\]
SPECIAL CONDITIONS OF SERVICE.

The locomotives described in the foregoing tables comprise designs adapted to the conditions of service usually prevailing, and the dimensions of boilers and fire-boxes are generally based upon the presumption that the fuel will be coal of ordinarily good quality. Any of these designs can, however, be modified to meet unusual requirements, and on pages 115 and 145 locomotives are shown having enlarged grate areas adapted for inferior coal. Trials of these locomotives having such special designs of fire-boxes and grates show that excellent results are obtained with coal ordinarily considered unsuitable for such use. To determine the suitability of any fuel for locomotives, a small quantity of same may be sent to the Baldwin Locomotive Works for analysis and laboratory tests, when, if practicable, specifications and designs will be submitted for locomotives guaranteed to meet the conditions thus ascertained.
COMPOUND LOCOMOTIVES.

Any of the locomotives described in the foregoing pages can be constructed upon the Baldwin or Vauclain compound system by substituting for the single-expansion cylinder diameters given, the equivalent diameters of compound cylinders indicated by the following table:

<table>
<thead>
<tr>
<th>Diameter of Cylinders</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single Expansion.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>10½&quot;</td>
</tr>
<tr>
<td>11½&quot;</td>
</tr>
<tr>
<td>13&quot;</td>
</tr>
<tr>
<td>14&quot;</td>
</tr>
<tr>
<td>15½&quot;</td>
</tr>
<tr>
<td>16½&quot;</td>
</tr>
<tr>
<td>17½&quot;</td>
</tr>
<tr>
<td>18½&quot;</td>
</tr>
<tr>
<td>19½&quot;</td>
</tr>
<tr>
<td>20½&quot;</td>
</tr>
<tr>
<td>21½&quot;</td>
</tr>
<tr>
<td>22½&quot;</td>
</tr>
<tr>
<td>23½&quot;</td>
</tr>
<tr>
<td>24½&quot;</td>
</tr>
<tr>
<td>25½&quot;</td>
</tr>
<tr>
<td>26½&quot;</td>
</tr>
<tr>
<td>27½&quot;</td>
</tr>
<tr>
<td>28½&quot;</td>
</tr>
<tr>
<td>29½&quot;</td>
</tr>
</tbody>
</table>
TRAIN OF TWENTY COMPOUND LOCOMOTIVES FOR CHICAGO AND SOUTH SIDE RAPID TRANSIT RAILROAD.
THE "VAUCLAIN" SYSTEM OF COMPOUND LOCOMOTIVES.

DESCRIPTION.

In designing the "Vauclain" system of compound locomotives, the aim has been:

1. To produce a compound locomotive of the greatest efficiency, with the utmost simplicity of parts and the least possible deviation from existing practice. To realize the maximum economy of fuel and water.

2. To develop the same amount of power on each side of the locomotive, and avoid the racking of machinery resulting from unequal distribution of power.

3. To insure at least as great efficiency in every respect as in a single-expansion locomotive of similar weight and type.

4. To insure the least possible difference in cost of repairs.

5. To insure the least possible departure from the method of handling single-expansion locomotives; to apply equally to passenger or freight locomotives for all gauges of track, and to withstand the rough usage incidental to ordinary railroad service.
The principal features of construction are as follows:

**Cylinders.**

The cylinders consist of one high-pressure and one low-pressure for each side, the ratio of the volumes being as nearly three to one as the employment of convenient measurements will allow. They are cast in one piece with the valve-chamber and saddle, the cylinders being in the same vertical plane, and as close together as they can be with adequate walls between them.

Where the front rails of the frames are single bars, the high-pressure cylinder is usually put on top, as shown in Fig. 1, but when the front rails of frames are double, the low-pressure cylinder is usually on top, as shown in Fig. 2.
The former (Fig. 1) is used in "eight-wheel" or American type passenger locomotives, and in "ten-wheeled" locomotives, while the latter (Fig. 2) is used in Mogul, Consolidation and Decapod locomotives; for the various other classes of locomotives the most suitable arrangement is determined by the style of frames.

Fig. 3 shows the arrangement of the cylinders in relation to the valve.

The valve employed to distribute the steam to the cylinders is of the piston type, working in a cylindrical steam-chest located in the saddle of the cylinder casting between the cylinders and the smoke-box, and as close to the cylinders as convenience will permit.

As the steam-chest must have the necessary steam passages cast in it and dressed accurately to the required sizes, the main passages in the cylinder casting leading thereto are cast wider
than the finished ports. The steam-chest is bored out enough larger than the diameter of the valve to permit the use of a hard cast iron bushing (Fig. 4). This bushing is forced into the steam-chest under such pressure as to prevent the escape of steam from one steam passage to another except by the action of the valve. Thus an opportunity is given to machine accurately all the various ports, so that the admission of steam is uniform under all conditions of service.

The valve, which is of the piston type,—double and hollow,—as shown by Fig. 5, controls the steam admission and exhaust of both cylinders. The exhaust steam from the high-pressure cylinder becomes the supply steam for the low-pressure cylinder.

As the supply steam for the high-pressure cylinder enters the steam-chest at both ends, the valve is in perfect balance, except the slight variation caused by the area of the valve-stem at the back end. This variation is an advantage in case the valve or its connection to the valve-rod should be broken, as it holds them together. Cases are reported where compound locomotives of
this system have hauled passenger trains long distances with broken valve-stems and broken valves, the parts being kept in their proper relation while running by the compression due to the variation mentioned. To avoid the possibility of breaking, it is the present practice to pass the valve-stem through the valve and secure it by a nut on the front end.

Cast iron packing rings are fitted to the valve and constitute the edges of the valve. They are prevented from entering the steam-ports when the valve is in motion by the narrow bridge across the steam-ports of the bushing, as shown in Fig. 4. The operation of the valve is clearly shown by Fig. 3, the direction of the steam being indicated by arrows.

When the low-pressure cylinder is on top, as shown by Fig. 2, the double front rail prevents the use of the ordinary rock-shaft and box, and the valve motion is then what is called "direct acting," changing the location of the eccentrics on the axle in relation to the crank-pin. When the low-pressure cylinder is underneath, the rock-shaft is employed, and the eccentrics are placed in the usual position, the valve motion is termed "indirect acting." Fig. 6 shows the relation of the eccentrics with and without the rocker-shaft. Great care should be taken by mechanics, when setting the valves on these locomotives, to observe this difference and not get the eccentrics improperly located on the axle. If the crank-pin is placed on the forward centre, the eccentric-rods will not be crossed when the rocker-arm or indirect motion is used, but will be crossed when no rocker-arm or direct motion is used. Serious complications have arisen from this being disregarded.
Various methods have been employed to transfer the motion from the links to the valve-rod. That which has proved most satisfactory is to attach the ends of the link and valve-rod to the arms of an intermediate oscillating shaft. This arrangement allows for the free vertical movement of the end of the rod attached to the link, and gives a parallel movement to the valve-rod. It also makes it convenient to obtain any required lateral variation in the line of the two rods. These parts are thoroughly case-hardened, and with reasonable care should wear indefinitely. It is preferable, however, to use a rock-shaft when possible, as there is then less departure from ordinary locomotive practice.

The cross-head is shown by Fig. 7. It is made of open-hearth cast steel and is machined accurately to size. The bearings for the guide-bars are covered with a thin coating of block tin, about one-sixteenth inch thick, which wears well and prevents heating. The holes for the piston-rods are bored so that the piston-rods will be perfectly parallel, and are tapered to insure a perfect fit.

The piston shown by Fig. 8 is made with either cast iron or cast steel heads, and is as light as possible. The rods, which are of triple-refined iron, are ground perfectly true to insure
good service in connection with metallic packing for the stuffing boxes. The diameter of both piston-rod is the same, both having equal work to perform. They are made large enough to resist strains due to any unequal pressure that may come upon them in starting the locomotive from a state of rest. The cross-head end has a shoulder which prevents the piston-rod being forced into the cross-head, and at the same time permits the cross-head end and the body of the piston-rod to be of one diameter, thus permitting vibratory strains to act throughout the entire length of the rod instead of concentrating them at the shoulder next to the cross-head. The piston-rods are secured to the cross-head by large nuts, and these in turn are prevented from coming loose by taper keys driven tightly against them.

It is obvious that in starting these locomotives with full trains from a state of rest, it is necessary to admit steam to the low-pressure cylinder as well as to the high-pressure cylinders, which is accomplished by the use of a starting valve (Fig. 9). This is merely a pass-by valve which is opened to admit steam to pass from one end of the high-pressure cylinder to the other end and thence through the exhaust to the low-pressure cylinder. This is more clearly shown at E in Fig. 10. The same cock acts as a cylinder cock for the high-pressure cylinder and is operated by the same lever that operates the ordinary cylinder cocks, thus making a simple and efficient device, and one that need not become disarranged. This valve should be kept shut as much as possible, as its indiscriminate use reduces the economy and makes the locomotive "logy."
As is usual in all engines, air valves are placed in the main steam passage of the high-pressure cylinder. Additional air valves, marked C and C¹ in Fig. 10, are placed in the steam passages of the low-pressure cylinders to supply them with sufficient air to prevent the formation of a vacuum, which would draw cinders into the steam-chest and cylinders.

Water relief valves (Fig. 11) are applied to the low-pressure cylinders, and attached to the front and back cylinder heads, to prevent the rupture of the cylinder in case a careless engineer should permit the cylinders to be charged with water, or to relieve excessive pressure of any kind.
In all other respects the locomotive is the same as the ordinary single-expansion locomotive.

**OPERATION.**

It is not surprising, in view of their differences of opinion respecting single-expansion locomotives, that there has been much controversy among engineers and firemen in regard to the operation of compound locomotives of this system. The first thing the engineer must learn is to use the reverse lever for what it is intended, that is, he must not hesitate to move it forward when ascending a grade if the locomotive shows signs of slowing up. The reverse quadrant is always so made that it is impossible to cut off steam in the high-pressure cylinder at less than half stroke, which avoids the damage that might ensue from excessive compression. It is perfectly practicable to operate the engine at any position of the reverse lever between half stroke and full stroke, without serious injury to the fire. When starting the locomotive from a state of rest, the engineer should always open the cylinder cocks to relieve the cylinders of condensation, and as the starting valve is attached to the cylinder cocks, this movement also admits steam to the low-pressure cylinder and enables the locomotive to start quickly and freely. In case the locomo-
tive is attached to a passenger train and standing in a crowded station, or in some position where it is undesirable to open the cylinder cocks, the engineer should move the cylinder cock lever in position to permit live steam to pass by into the low-pressure cylinder, thus enabling the locomotive to start quickly and uniformly, without any of the jerking motion so common in two-cylinder or cross-compound locomotives. After a few revolutions have been made and the cylinders are free from water caused by condensation or priming, the engineer should move the cylinder cock lever into the central position, causing the engine to work compound entirely. This should be done before the reverse lever is disturbed from its full gear position. The reverse lever should never be “hooked up,” thereby shortening the travel of the valve, until after the cylinder cock lever has been placed in the central position. It is often necessary to open the cylinder cocks when at full speed, to allow water to escape from the cylinders, especially when the engineer is what is commonly called a “high-water” man, and in such case no disadvantage is experienced and the reverse lever need not be disturbed. The starting device should not be used for any purpose other than the “starting” of the train. After the train is in motion it should not be used. Cases have been observed where the engineers use it all the time and have the reverse lever “hooked up” in the top notch (half stroke), in consequence of which the locomotive will slow down to a low speed whilst burning an excessive amount of coal. Such running must result in general dissatisfaction.

The starting device is useful in emergencies, as, for instance, when stalling with a heavy train on a grade, if live steam is admitted to the low-pressure cylinder sufficient additional power is obtained to start the train and take it over the grade. This should be resorted to only in emergencies, and allowance should be made for the extra repairs caused by frequent cases of this kind.

On account of the very mild exhaust, the fireman should carry the fire as light as possible. A little practice will enable him to judge how to get along with the least amount of fuel.

The following diagram (Fig. 12) shows the difference in the amount of water required to do the work at various points of
cut-off in compound and single-expansion locomotives. The upper line shows the rate of water consumption per horse-power developed for several points of cut-off in single-expansion locomotives, whilst the lower line shows the same for compound locomotives. It will be observed that the most economical point of cut-off is about one-quarter stroke on the single-expansion locomotive, and about five-eighths stroke on the compound locomotive. It is also noticeable that the water-rate per horse-power varies very little on the compound locomotive when the reverse lever is moved towards full gear or longer cut-off, but in the single-expansion engine it increases rapidly, causing engineers to remark that they cannot "drop her a notch" on account of "getting away with the water." This does not occur with the compound locomotive when the reverse lever is moved forward towards full gear, and no engineer should open the pass-by valve, admitting live steam to the low-pressure cylinder, until the last notch has been used on the quadrant and the engine is about to stall.

![Diagram of Point of Cut-off](image)
It is also desirable to move the reverse forward a notch before the locomotive slows down too much, as it is better to preserve the momentum of the train than to slow down and again have the trouble of accelerating. In this way both coal and water are wasted. If these instructions are observed the locomotive will work satisfactorily.

REPAIRS.

On account of the great similarity to single-expansion locomotives, mechanics familiar with the latter have no difficulty in understanding these compound locomotives. There is no new element of repairs introduced,—no complicated starting or reducing valves, such as are common to other systems of compound locomotives.

The cross-heads, when badly worn, may, in a short time, be retinned by any coppersmith; in fact, an ordinary laborer can be taught this in a few days. The cross-head is heated warm enough to melt solder, and is then cleaned and wiped with solder, using dilute muriatic acid, such as tinsmiths use in soldering. Block tin is then poured against the surfaces so prepared, to which it adheres. A piece of iron placed alongside the cross-head can be used to regulate the thickness.

The cross-head is then put on a planer to true it up, care being used not to let the tool “dig in” and tear off the tin.

The pistons are treated the same as in ordinary single-expansion engines. The packing-rings in the low-pressure cylinder require renewal more frequently than those in high-pressure cylinders. It is also more difficult in compound cylinders to detect faulty packing-rings, and they are sometimes noticed only by the locomotive failing in steam and in not making time on the road.

The piston-valves should last a long time if properly lubricated, but when the bushing (Fig. 4) and valve (Fig. 5) are worn enough to require attention, the bushing should be bored out and new rings put in the valve; very often it is not necessary to bore the bushings, merely to put new packing-rings in the valve.

After the bushings (Fig. 4) have been bored several times, larger valves may be fitted to them so as to have as little play
as possible. A very convenient type of boring bar for boring out the bushings has been designed, by which the work can be done without taking down the back head of the steam-chest. It is possible with this tool to bore out the bushings in less time than required to face a valve seat on a single-expansion locomotive.

When putting new bushings in the steam-chests, the device shown in Fig. 13 may be used, which gives the required power and is slow enough to permit the bushing to accommodate itself to the cylinder casting.

When extracting old bushings, it is best to split them with a narrow cape chisel—they are only fit for scrap when removed, and can be much more quickly removed this way than to attempt to draw them out with draw screws.

Enough attention should be given the starting valves to insure their moving in harmony with each other. Engineers sometimes strain the cylinder cock shaft, which causes one starting valve to open and the other to remain shut; this causes the exhaust to beat unevenly, and the engineer is apt to complain that the valves are out of square. Before altering the valve motion on these
engines, make sure that the starting valves open and close simultaneously, and examine low-pressure pistons and piston valve for broken packing-rings. In one case an engineer ran his locomotive two days without any piston-head on one of the low-pressure pistons, and even then could not tell what was the matter, only that the locomotive sounded "lame" and did not make good time with the train. Men were put to work to locate the trouble, and found it, to the great surprise of the engineer.

ADDENDA.

It is not claimed for compound locomotives that a heavier train can be hauled at a given speed than with a single-expansion locomotive of similar weight and class. No locomotive can haul more than its adhesion will allow; but the compound will, at very slow speed on heavy grades, keep a train moving where a single-expansion locomotive will slip and stall. This is due to the pressure on the crank-pins of the compound being more uniform throughout the stroke than is the case with the single-expansion locomotive.

The principal object in compounding locomotives is to effect fuel economy, and this economy is obtained,—

1. By the consumption of a smaller quantity of steam in the cylinders than is necessary for a single-expansion locomotive doing the same work.

2. The amount of water evaporated in doing the same work being less in the compound, a slower rate of combustion combined with a mild exhaust produces a higher efficiency from the coal burned.

In a stationary engine, which does not produce its own steam supply, it is of course proper to measure its efficiency solely by its economical consumption of steam. In an engine of this description the boilers are fired independently, and the draft is formed from causes entirely separate and beyond the control of the escape of steam from the cylinders; hence, any economy shown by the boilers must of necessity be separate and distinct from that which may be effected by the engine itself. In a locomotive, however, the amount of work depends entirely upon the
weight on the driving-wheels, the cylinder dimensions being proportioned to this weight; and whether the locomotive is compound or single-expansion, no larger boiler can be provided, after allowing for the wheels, frames, and other mechanism, than this weight permits. Therefore, the heating surfaces and grate area are practically the same in both types, and the evaporative efficiency of both locomotives is determined by the action of the exhaust, which must be of sufficient intensity in both cases to generate the amount of steam necessary for utilizing, to the best advantage, the weight on the driving-wheels. This is a feature that does not appear in a stationary engine, so that the compound locomotive cannot be judged by stationary standards, and the only true comparison to be made is between locomotives of similar construction and weight, equipped in one case with compound and in the other with single-expansion cylinders.

One of the legitimate advantages of the compound system is that, owing to the better utilization of the steam, less demand is made upon the boiler, which enables sufficient steam-pressure to be maintained with the mild exhaust, due to the low tension of the steam when exhausted from the cylinders. This milder exhaust does not tear the fire, nor carry unconsumed fuel through the flues into the smoke-box and thence out of the smoke-stack, but is sufficient to maintain the necessary rate of combustion in
the fire-box with a decreased velocity of the products of combustion through the flues.

The heating surfaces of a boiler absorb heat units from the fire and deliver them to the water at a certain rate. If the rate at which the products of combustion are carried away exceeds the capacity of the heating surfaces to absorb and deliver the heat to the water in the boiler, there is a continual waste that can be overcome only by reducing the velocity of the products of combustion passing through the tubes. This is effected by the compound principle. It gives, therefore, not only the economy due to a smaller consumption of water for the same work, but the additional economy due to slower combustion. It is obvious that these two sources of economy are interdependent.

The improved action of the boiler can be obtained only by the use of the compound principle, while the use of the compound principle enables the locomotive to develop its full efficiency under conditions which in a single-expansion locomotive would require a boiler of capacity so large as to be out of the question under the circumstances usually governing locomotive construction. It is therefore evident that where both locomotives are
RACK AND ADHESION LOCOMOTIVE, CIA. MINERA DE PENOLES.
exact duplicates in all their parts, excepting the cylinders, the improved action of the boiler is due entirely to the compound principle, and the percentage of economy should be based upon the total saving in fuel consumption, and not upon the water consumption, as in stationary practice.

For the benefit of those who may test these locomotives, the following method is presented of determining the water rate per horse-power from an indicator diagram:

\[ S = \text{Stroke in inches.} \]
\[ C = \text{Per cent. of stroke completed at cut-off.} \]
\[ P = \text{Pressure of steam at cut-off, taken from zero.} \]
\[ W_P = \text{Weight per cubic foot of steam at } P \text{ pressure.} \]
\[ H = \text{Per cent. of stroke uncompleted at compression.} \]
\[ Q = \text{Pressure of steam at compression, taken from zero.} \]
\[ W_Q = \text{Weight per cubic foot of steam at } Q \text{ Pressure.} \]
\[ E = \text{Per cent. of clearance in H.-P. cylinders.} \]
\[ A = \text{Area of H.-P. cylinders.} \]
\[ P = \text{M.E.P. of H.-P. cylinders.} \]
\[ a = \text{Area of L.-P. cylinders.} \]
\[ K = \text{M.E.P. of L.-P. cylinders.} \]
\[ N = \text{Number of revolutions per minute.} \]
\[ r = \text{Ratio } \frac{a}{A}; \text{ hence, } a = A \times r. \]

All calculations are made on the basis of the high-pressure cylinder doing the work of both cylinders.

The volume of the piston displacement is \( A \times S \), and the volume at cut-off is \( A \times S \times C \), since \( C \) is the proportion of stroke completed at cut-off. The volume of \( N \) revolutions would be \( A \times N \times S \times C \). As there are two strokes of the piston for each revolution, and there is an engine on each side of the locomotive, assuming that both engines are doing exactly the same work, there would be four strokes per revolution; hence \( 4 \times A \times N \times S \times C \) is the volume of piston displacement at cut-off for one revolution. Since the clearance-space is expressed in percentage of the piston displacement of one stroke, and which space is filled at each stroke, the volume of the clearance-space for one revolution would be \( 4 \times A \times N \times S \times E \). The sum of these two quantities divided by 1728 will give the volume in cubic feet. The indicator-card gives the pressure at cut-off, and a reference to the steam-table will give the weight of steam at that pressure; hence, the amount of steam
used per revolution becomes \( \left( \frac{4A\, NSC + 4\, A\, NES}{1728} \right) Wp \). But there is a certain amount of steam saved at compression, and the volume at this point would be \( \frac{4A\, NSH + 4\, A\, NES}{1728} \). The volume of the clearance-space being again taken into consideration. Since this steam is saved by compression, it should be deducted from the amount used, and the formula becomes:

\[
\left( \frac{4A\, NSC + 4\, A\, NES}{1728} \right) Wp - \left( \frac{4A\, NSH + 4\, A\, NES}{1728} \right) Wq; \text{ or } \frac{4A\, NS}{1728} \left( (C + E) Wp - (H + E) Wq \right). \]

The H.-P. equals \( \frac{4A\, NS (P + rK)}{12 \times 33,000} \). Then the water rate per minute would be

\[
\frac{4A\, NS}{1728} \left( (C + E) Wp - (H + E) Wq \right), \text{ or } \frac{229.16}{P + rK} (C + E) Wp - (H + E) Wq; \text{ and the rate per hour would be } \frac{60 \times 229.16}{P + rK},
\]

or \( \frac{13750}{P + rK} ((C + E) Wp - (H + E) Wq) \), which formula is to be used.

If it is desired to get the steam at release H.-P., substitute the value of the point \( R \) and pressure \( t \), also \( S \times R \), respectively, for \( C, p \), and \( C \times S \). See Figs. 14 and 15.

---

**Fig. 14.**

M.E.P. H.-P. cylinder . . . . 87 pounds  Clearance . . . . .08
M.E.P. L.-P. cylinder . . . . 32 pounds  Ratio . . . . 2.87 to 1
M.E.P. referred to H.-P. cylinder . . . . . . . . . . . . . . . . . . . . . . 178.84
M.E.P. referred to L.-P. cylinder . . . . . . . . . . . . . . . . . . . . . . 62.31

\[ 178.84 = P + rK \]
\[ 62.31 = K + \frac{P}{r} \]

**Fig. 15.**
135.3
14.7
150.0 = .3376 pound per cubic foot of steam at cut-off H.-P. cylinder.
60.3
14.7
75.0 = .1756 pound per cubic foot of steam at compression H.-P. cylinder.
30.
14.7
44.7 = .1079 pound per cubic foot of steam at point on L.-P. expansion line.
16.
14.7
30.7 = .0758 pound per cubic foot of steam at compression L.-P. cylinder.

\[
\frac{13750}{178.84} = 76.88 \\
\frac{13750}{62.31} = 220.67 \\
(.677 + .08) \times .3376 = .2556 \\
(.238 + .08) \times .1756 = .0558 \\
.2556 \\
.0558 \\
.1908 \\
.1908 \times 76.88 = 15.36 \text{ pounds steam at cut-off H.-P. cylinder.} \\
(.744 + .08) \times .1079 = .0889 \\
(.083 + .08) \times .0758 = .0124 \\
.0889 \\
.0124 \\
.0765 \\
.0765 \times 220.67 = 16.89 \text{ pounds steam at point on expansion line L.-P. cylinder.}
\]

RACK LOCOMOTIVE, S. ELLERO AND VALLOMBROSA.
The following method of combining indicator diagrams, devised by Mr. George H. Barrus, is given also, and is generally accepted by all engineers as the correct method.

METHOD OF COMBINING CARDS.
(FURNISHED BY MR. GEORGE H. BARRUS.)

The method employed corresponds to that given in Rankine's book on the steam-engine, but is here given more in detail. This method will be clearly understood if it is remembered that every point in the expansion line of the L.-P. card of the combined diagram should correctly represent the pressure and volume of the steam at the corresponding point of the stroke of the low-pressure piston, the volume being measured from the clearance line of that cylinder. Referring to Fig. 16, the H.-P. diagram is an exact copy of the original except in point of scale.
The L.-P. diagram at the bottom of Fig. 16 is also an exact copy of the original on the same scale of pressure as the H.-P. diagram, though of different length; this last having the same ratio to the length of the H.-P. diagram as the area of the piston of the L.-P. cylinder has to the area of that of the high; in this case 2.9. The length of the H.-P. diagram on the scale of the chart is 100, as indicated, and of the L.-P. diagram 290.

To draw the L.-P. portion of the diagram, it may be divided into, say, ten equal parts, and the points of the division marked \(a, b, c, d,\) and \(e\). The various points on the combined L.-P. dia-

FiguRE. FOUR-COUPLED SIX-WHEEL TANK LOCOMOTIVE STATE TRANSCAUCASIAN.

gram are located horizontally, so as to mark the various volumes occupied by the steam at the respective points, as already noted. Below the point of cut-off, which is located at .6 of the stroke, or at the point \(9\), the combined diagram is an exact reproduction of the lower diagram. The points in this portion of the diagram showing volume, that is, the horizontal distances, represent the volumes of the L.-P. cylinders at those points, plus the clearance of the same. The clearance is 6.5 per cent. of the stroke of the L.-P. piston, or is 18.9 points of division on the scale of the chart. The distance, for example, of the point \(h\) from the clearance line on the combined diagram, will be .7 of 290 ÷ 19, or \(203 - 19 = 222\), and likewise for the remaining points below the cut-off. The
points in the expansion line of the L.-P. combined diagram, above the points of cut-off, lie farther to the left, for the reason that the volume of the steam expanding is not only the apparent volume of that contained in the L.-P. cylinder, but in addition, that of the steam being exhausted from the H.-P. cylinder (the valve being open between the two), and that contained in the clearance space of the same. Take, for instance, the point \( a' \), or the initial point of the diagram; the volume here is that of the H.-P. cylinder, the clearance of the H.-P. cylinder, and the clearance of the L.-P. cylinder. The point \( a' \) is therefore laid off at a distance of 19 divisions to the left of the end of the H.-P. diagram, or at the division marked 119 on the chart. At the point \( b' \) the volume of the steam has been increased, corresponding to 1-10 of the L.-P. cylinder, or 29 divisions, but at the same time it has been reduced correspondingly to 1-10 of the H.-P. cylinder, or to 10 divisions, so that the combined effect is to increase the volume 19 divisions to the left of the point \( a' \). The remaining points from \( b' \) to \( g' \) are laid off successively at distances of 19 divisions. At \( g' \), where the valve closes and cuts off communications between the H.-P. and L.-P. cylinders,
the volume contracts, and this feature is represented by the horizontal line $g' g''$. To obtain the remaining points of the combined diagram from $a'$ to $q'$, the various points are laid off, so that the horizontal distances from the expansion line shall be the same as those in the lower diagram. In this way the area of the combined diagram is exactly the same as that of the original diagram. The dotted line $x w y$ shows the position of the combined diagram, supposing the intermediate space within the valve were empty when the H.-P. cylinder exhausted, assuming that the volume of this space is 20 per cent. of the volume of the H.-P. cylinder. In reality this space is not empty, but is always filled with steam somewhat above the pressure at cut-off in L.-P. cylinder.
SUGGESTIONS FOR RUNNING A VAUCLAN
FOUR-CYLINDER COMPOUND
LOCOMOTIVE.

In starting the locomotive with a train, place the reverse lever
in full forward position, throw the cylinder-cock lever forward,
which operation opens the starting-valve and allows live steam
to pass to the low-pressure cylinder. The throttle is then

opened, and as soon as possible when the cylinders are free of
water and the train is under good headway, the cylinder cocks
and starting-valve should be closed. As the economy of a com-
pound locomotive depends largely on its greater range of expan-
sion, the engineer should bear in mind that in order to get the best results he must use his reverse lever. After the starting-valve is closed and as the speed of the train increases, the reverse lever should be hooked back a few notches at a time until the full power of the locomotive is developed. If after moving the reverse lever to the last notch, which cuts off the steam at about half stroke in the high-pressure cylinder, it is found that the locomotive develops more power than is required, the throttle must be partially closed and the flow of steam to the cylinder reduced. On slightly descending grades the steam may be throttled very close, allowing just enough in the cylinders to keep the air-valves closed. If the descent is such as to prevent the use of steam, close the throttle and move the reverse lever gradually to the forward notch and move the starting-valve lever to its full backward position. This allows the air to circulate either way through the starting-valve from one side of the piston to the other, relieves the vacuum, and prevents the oil from being blown out of the cylinder. On ascending grades with heavy loads as the speed decreases the reverse lever should be moved forward sufficiently to keep up the required speed. If, after the reverse lever is placed in the full forward notch, the speed still
decreases and there is danger of stalling, the starting-valve may be used, admitting steam to the low-pressure cylinders. This should be done only in cases of emergency and the valve closed as soon as the difficulty is overcome.

The tractive power of Vauclain four-cylinder compound locomotives may be ascertained by the following formula:

\[
\frac{C^2 \times S \times \frac{3}{4} P}{D} + \frac{e^2 \times S \times \frac{4}{3} P}{D} = T; \text{ in which}
\]

\(C=\text{Diameter of high-pressure cylinder in inches.}\)
\(e=\text{Diameter of low-pressure cylinder in inches.}\)
\(S=\text{Stroke of piston in inches.}\)
\(P=\text{Boiler pressure in pounds.}\)
\(D=\text{Diameter of driving wheels in inches.}\)
\(T=\text{Tractive power.}\)

The first Vauclain compound locomotive was built in 1889; in the year 1890 three more were built, followed in 1891 by 82, in 1892 by 213, in 1893 by 160, in 1894 by 30, in 1895 by 51, in 1896 by 173, in 1897 by 86, in 1898 by 235, in 1899 by 241, and in 1900 there have been built or orders have been received for 517. Those already shipped are distributed among the various railroad companies as follows:

Algoma Central ........................................ 1
Altoona, Clearfield and Northern .................... 1
Altoona and Phillipsburg Connecting ................. 2
Arizona and South Eastern ............................ 1
Atlantic Coast Line .................................. 2
Bahia Extension, Brazil ............................... 11
Baldwin Locomotive Works, stock ................... 2
Baltimore and Ohio .................................. 81
Baltimore and Ohio Southwestern ................... 47
Barranquilla Railway .................................. 2
Bavarian State ......................................... 2
Brazilian Industrial Improvement Co .................. 3
Brooklyn Wharf and Warehouse Co .................... 2
Buffalo, Rochester and Pittsburg .................... 6
Buenos Aires Western .................................. 2
Calumet and Hecla .................................... 1
Cambria Steel Co .................................... 2
Canadian Pacific .................................... 34
NARROW-GAUGE LOCOMOTIVES.

Central Dominican ........................................... 3
Central of Georgia ........................................... 3
Central Railroad of Brazil .................................. 23
Central Railroad of New Jersey ......................... 14
Chicago and Alton ........................................... 10
Chicago and Erie ............................................ 2
Chicago and Grand Trunk .................................. 1
Chicago and Great Western ............................... 5
Chicago and Northwestern ............................... 3
Chicago and South Side .................................. 45
Chicago, Burlington and Quincy ......................... 2
Chicago, Milwaukee and St. Paul ....................... 79
Chicago, Rock Island and Pacific ...................... 16
Chilean State Railways ................................... 4
Chinese Eastern ............................................ 148
Cia Minera de Peñoles, Mexico (rack) .................. 4

TEN-WHEEL PASSENGER LOCOMOTIVE, Altoona Clearfield & Northern Railroad.
<table>
<thead>
<tr>
<th>Company Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cincinnati, Hamilton and Dayton</td>
<td>1</td>
</tr>
<tr>
<td>Cincinnati, New Orleans and Texas Pacific</td>
<td>12</td>
</tr>
<tr>
<td>Cleveland, Akron and Columbus</td>
<td>2</td>
</tr>
<tr>
<td>Columbia University</td>
<td>1</td>
</tr>
<tr>
<td>Cornwall and Lebanon</td>
<td>1</td>
</tr>
<tr>
<td>Consolidation Coal Co.</td>
<td>1</td>
</tr>
<tr>
<td>Delaware, Lackawanna and Western</td>
<td>1</td>
</tr>
<tr>
<td>Detroit and Lima Northern</td>
<td>1</td>
</tr>
<tr>
<td>Elgin, Joliet and Eastern</td>
<td>1</td>
</tr>
<tr>
<td>Engenho Central, Brazil</td>
<td>1</td>
</tr>
<tr>
<td>Erie</td>
<td>73</td>
</tr>
<tr>
<td>F. C. del Norté</td>
<td>3</td>
</tr>
<tr>
<td>F. C. de Merida á Valladolid</td>
<td>1</td>
</tr>
<tr>
<td>Fitchburg</td>
<td>7</td>
</tr>
<tr>
<td>French State</td>
<td>5</td>
</tr>
<tr>
<td>Frick Coke Co.</td>
<td>5</td>
</tr>
<tr>
<td>Gordon, Simon James</td>
<td>3</td>
</tr>
<tr>
<td>Great Northern</td>
<td>7</td>
</tr>
<tr>
<td>Government New South Wales, Australia</td>
<td>2</td>
</tr>
<tr>
<td>Grand Trunk</td>
<td>10</td>
</tr>
<tr>
<td>Hamilton and Dundas</td>
<td>1</td>
</tr>
</tbody>
</table>
Hawaiian Agricultural Co. ........................................ 1
Hidalgo Railroad, Mexico ........................................ 1
Intercolonial Railway of Canada ................................. 20
International Construction Co. ................................ 1
Interoceanic of Mexico ........................................... 2
Iowa Central ......................................................... 7
Jacksonville, Tampa and Key West .............................. 1
Kentucky Union ...................................................... 1
Lehigh and Lackawanna ........................................... 2
Lehigh Coal and Navigation Co. ................................. 2
Lehigh Valley ....................................................... 64
Leopoldina Railway, Brazil ....................................... 1
Long Island ......................................................... 15
Longdale Iron Co. .................................................. 3
Los Angeles Terminal ............................................. 1
McCloud River ...................................................... 1
Marietta and North Georgia ...................................... 1
Mexican National ................................................... 32
Mineral Range ...................................................... 1
Minneapolis, St. Paul and Sault Ste. Marie ..................... 1

MOGUL LOCOMOTIVE, BRAZILIAN INDUSTRIAL IMPROVEMENT CO.

Missouri, Kansas and Texas ...................................... 16
Mogyana Railroad, Brazil ......................................... 1
Moscow Kazan ...................................................... 2
Moscow-Keif-Voronesh ........................................... 33
Moscow-Windau-Ribinsk ......................................... 20
New Orleans and Northeastern .................................. 4
NARROW-GAUGE TEN-WHEEL LOCOMOTIVE, MEXICAN NATIONAL RAILROAD.
NARROW-GAUGE LOCOMOTIVES.

<table>
<thead>
<tr>
<th>Location</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>2</td>
</tr>
<tr>
<td>New York and New England</td>
<td>12</td>
</tr>
<tr>
<td>New York, Chicago and St. Louis</td>
<td>1</td>
</tr>
<tr>
<td>New York, Pennsylvania and Ohio</td>
<td>8</td>
</tr>
<tr>
<td>New Zealand</td>
<td>4</td>
</tr>
<tr>
<td>Norfolk and Southern</td>
<td>3</td>
</tr>
</tbody>
</table>

NARROW-GAUGE TEN-WHEEL LOCOMOTIVE, OESTE DE MINAS RAILWAY, BRAZIL.

<table>
<thead>
<tr>
<th>Location</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norfolk and Western</td>
<td>46</td>
</tr>
<tr>
<td>North Chicago Street Railway</td>
<td>1</td>
</tr>
<tr>
<td>Northern Pacific</td>
<td>5</td>
</tr>
<tr>
<td>Norwegian State Railways</td>
<td>4</td>
</tr>
<tr>
<td>Oeste de Minas, Brazil</td>
<td>22</td>
</tr>
<tr>
<td>Ottawa, Arnprior and Parry Sound</td>
<td>28</td>
</tr>
</tbody>
</table>

"AMERICAN" TYPE LOCOMOTIVE, PAULISTA RAILWAY BRAZIL.

<table>
<thead>
<tr>
<th>Location</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oosoori Railway of Russia</td>
<td>1</td>
</tr>
<tr>
<td>Paulista Railway, Brazil</td>
<td>52</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>7</td>
</tr>
</tbody>
</table>
Pennsylvania and Northwestern .................................. 10
Pernambuco Extension, Brazil ..................................... 7
Philadelphia and Reading ........................................... 129
Philadelphia and Reading Coal and Iron Co. .................... 4
Pikes Peak (rack) .................................................. 5
Pittsburg, Cincinnati, Chicago and St. Louis ................. 1
Plymouth Cordage Co. ............................................. 1
Ramul Dumont, Brazil ............................................. 1
Ramul Ferreo Campineiro, Brazil ................................ 2
Richmond and Danville ............................................ 1
Rio Grande Western ............................................... 4
Rockaway Valley .................................................. 1

**PLANTATION LOCOMOTIVE, RAMAL DUMONT, BRAZIL.**

Rumford Falls and Rangeley Lakes .............................. 1
Salinas ..................................................................... 1
Sandusky and Columbus Short Line .............................. 2
San José and Alum Rock, Hugh Centre ....................... 1
Santo Domingo (rack) ............................................. 1
Sanyo Railway, Japan ............................................. 7
Seaboard Air Line .................................................. 2
S. Ellero and Vallombrosa (rack) ............................... 1
Sinnemahoning Valley ............................................ 1
Sormova Co., Ltd., Russia ....................................... 3
Southeastern Russia ............................................... 66
Southern .................................................................. 1
State Transcaucasian, Russia ................................... 8
FRONT VIEW OF VAUCLAIN COMPOUND LOCOMOTIVE.
<table>
<thead>
<tr>
<th>Company</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>St. Louis and San Francisco</td>
<td>5</td>
</tr>
<tr>
<td>Texas and Pacific</td>
<td>1</td>
</tr>
<tr>
<td>Texas Central</td>
<td>4</td>
</tr>
<tr>
<td>Tikuho Railway of Japan</td>
<td>1</td>
</tr>
<tr>
<td>Toledo, Ann Arbor and North Michigan</td>
<td>6</td>
</tr>
<tr>
<td>Union Pacific</td>
<td>20</td>
</tr>
<tr>
<td>Union Terminal of Kansas City</td>
<td>1</td>
</tr>
<tr>
<td>United Verde Copper Co.</td>
<td>2</td>
</tr>
<tr>
<td>Virginia and Southwestern</td>
<td>6</td>
</tr>
<tr>
<td>Victorian Railways, Australia</td>
<td>1</td>
</tr>
<tr>
<td>Vladiaucase of Russia</td>
<td>80</td>
</tr>
<tr>
<td>Wabash</td>
<td>3</td>
</tr>
<tr>
<td>Wellington and Manawatu, New Zealand</td>
<td>4</td>
</tr>
<tr>
<td>Western Counties, Nova Scotia</td>
<td>2</td>
</tr>
<tr>
<td>Western Maryland</td>
<td>2</td>
</tr>
</tbody>
</table>

**Decapod Locomotive, State Transcaucasian Railway of Russia.**

<table>
<thead>
<tr>
<th>Company</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western New York and Pennsylvania</td>
<td>1</td>
</tr>
<tr>
<td>Western Railway of Havana</td>
<td>1</td>
</tr>
<tr>
<td>West Virginia Central and Pittsburg</td>
<td>2</td>
</tr>
<tr>
<td>White Pass and Yukon</td>
<td>2</td>
</tr>
<tr>
<td>Wilmington Street Railway</td>
<td>1</td>
</tr>
</tbody>
</table>

Comparative tests of Vauclain compound and single-expansion locomotives have been made by capable engineers, and usually under the supervision of the locomotive department of the respective lines.

Following is a summary of the general results:

In July, 1891, a test was made in freight service by Mr. John Hickey, Superintendent of Motive Power and Machinery of the Northern Pacific Railroad, the work being under the immediate
supervision of Mr. O. H. Reynolds, then Mechanical Engineer for the company, of the compound Mogul locomotive No. 587, and a single expansion Mogul No. 584, both being of same dimensions and weight and differing only in the cylinders and boiler pressure.

Separate tests were made, (1) with both locomotives carrying 170 pounds of steam pressure, (2) with the compound carrying 170 and the single-expansion carrying 150 pounds pressure, and (3) with both locomotives carrying 150 pounds pressure. The average steam pressure carried for all trips by the compound locomotive was 157.3, and by the single-expansion locomotive was 151.9 pounds. The course was between Staples, Minnesota, and Fargo, Dakota, a distance of 108.7 miles. The trains were selected to give each locomotive as nearly the same weight as possible.

Five trips were run with both locomotives carrying 170 pounds of steam, the average result showing a saving in fuel of 28 per cent. in favor of the compound locomotive. On one trip where the compound locomotive was loaded to its most economical limit, a saving of 53.5 per cent. was made.

Four trips were run with the single-expansion locomotive carrying 150 pounds of steam and the compound carrying 170 pounds, the average result showing a saving of 20.9 per cent. in favor of the compound locomotive. One trip was run with both locomotives carrying 150 pounds of steam, which showed
a saving of 18.3 per cent. in favor of the compound locomotive.

The general average of the ten trips gave a total saving in favor of the compound locomotive of 22.2 per cent. in fuel and 11.27 per cent. in water evaporated per pound of coal. The waste gases in the smoke-box of the single-expansion locomotive reached a temperature of 878 deg., while the highest registered by the compound was 590 deg. Fahrenheit.

The highest smoke-box vacuum in the single-expansion loco-

motive was 6 ounces or about 10 inches, and in the compound 4 ounces or about 63/4 inches.

In August and September, 1891, a test was made in freight service by Mr. Allen Vail, General Master Mechanic of the Western New York and Pennsylvania Railroad, of the compound consolidation locomotive No. 175, and single-expansion consolidation No. 169, both locomotives being identical except the cylinders.

The tests were made with the compound locomotive carrying 170 pounds steam pressure, and the single-expansion locomotive carrying 150 pounds. The average pressure carried for all trips by the compound was 166 pounds, and by the single-expansion 147.7 pounds. The course was between Buffalo and Olean, N. Y., a distance of 70 miles. Three round trips were run, with an average increase in favor of the compound locomotive of 36.2
per cent. in weight of train hauled per pound of coal, and of 17.9 per cent. in water evaporated per pound of coal.

The average temperature of the smoke-box gases was 690 deg. in the single-expansion locomotive, and 630 deg. in the compound.

The average smoke-box vacuum in the single-expansion locomotive was 6.4 inches, and in the compound 2.9 inches.

TEN-WHEEL PASSENGER LOCOMOTIVE, MISSOURI, KANSAS & TEXAS RAILWAY.

In January, 1892, a test was made in freight service by Mr. David Holtz, Master of Machinery of the Western Maryland Railroad, of compound consolidation locomotive No. 45, and a single-expansion consolidation locomotive No. 43, of similar size and dimensions with the exception of the cylinders.

The test was made on a mountain grade 10 miles in length with a total ascent of 1000 feet. At several points the grade reaches 105.6 feet per mile, with numerous sharp curves.

A single trip was made with each locomotive under similar conditions with the same train, the single-expansion locomotive carrying 147 pounds steam pressure, and the compound carrying 175 pounds.

The saving in fuel was 44.9 per cent. in favor of the compound locomotive. Quite a saving was also noted in the consumption of water.

In January, 1892, several tests were made, both in passenger and freight service, by Mr. R. H. Soule, Superintendent of Motive Power of the Norfolk and Western Railroad,—the work being under the supervision of Mr. George R. Henderson, Chief
Draughtsman,—of the ten-wheel compound locomotive No. 82. The test was made and the data of the performance noted for comparison with tests which had previously been made with similar single-expansion locomotives in the same service.

Mogul Freight Locomotive, Northern Pacific Railroad.

The average steam pressure carried by the compound locomotive was 181 pounds, and that carried by the single-expansion locomotives with which it was compared was 139 pounds. The course over which the run was made in passenger service was between Roanoke and Bristol, a distance of 150 miles, and that for freight service between West Roanoke and Radford, a dis-

Six-Coupled Tank Locomotive, Chinese Eastern Railway.
tance of 41.6 miles. Four round trips were made with a passenger train and two round trips with freight. Comparing the general average with that of the single-expansion locomotives, it was found that the compound showed a saving in fuel of nearly 38 per cent. per ton per mile, with a corresponding saving in water.

![Narrow-Gauge Mogul Freight Locomotive Tikuho Railway, Japan](image)

Average smoke-box vacuum was in the compound 2¼ inches, and in the single-expansion 5 inches.

In 1892 a test was made on the Chicago, Milwaukee and St. Paul Railroad, by a committee appointed by the Master Mechanics' Association, of compound locomotive No. 827, and the single-expansion locomotive No. 822, of precisely the same construction excepting the cylinders. The tests extended over a period of nearly two months, sixty complete single trips being made, the locomotives carrying 180 and 200 pounds pressure of steam. The route selected was from Milwaukee to Portage, a distance of 91 miles.

The average economy of the compound locomotive was placed at 16.9 per cent. in fuel and 14.1 per cent. in water.

In September and October, 1892, a test was made in passenger service by Mr. James Meehan, Superintendent of Motive Power and Machinery of the Cincinnati, New Orleans and Texas Pacific Railway, of the ten-wheel compound locomotive No. 604, and a single expansion locomotive of the same type, No. 531.

The tests were made with both limited and accommodation trains, the compound locomotive carrying 180 pounds pressure
of steam, and the single expansion 140 pounds. The average steam pressure shown by the indicator cards was for the compound 173.3 pounds, and for the single-expansion 133.3 pounds.

![Fast Passenger Locomotive, Philadelphia & Reading Railroad.]

The distance run was 93.3 miles. Ten trips were made with each locomotive. The average results showed a total saving in consumption of fuel in favor of the compound locomotive of 35½ per cent. in pounds of coal per car mile, but as the compound locomotive had a somewhat larger amount of heating surface, it was thought best to place the gain at 25 per cent., in order to be sure and on the safe side.

In November, 1893, a series of tests was made in freight service by Mr. Chas. M. Jacobs, Consulting Engineer of the Long Island Railroad, and his assistant, Mr. J. V. Davies, of the ten-wheel freight locomotive No. 145 and the ten-wheel single-expansion locomotive No. 138. It was arranged in this test to run three consecutive trips with each locomotive with a train of twenty loaded cars set apart for the purpose, in order that each locomotive should do the same work under the same conditions. The steam pressure carried by the compound locomotive was 180 pounds and by the single-expansion locomotive 145 pounds.

The average steam pressure was, for the compound, 166.7 pounds, and for the single-expansion 126 pounds.

The course was between Hempstead Crossing and Ronkon-
koma, and the train was hauled the round trip twice, making a distance of 113.78 miles.

The general average of these trips showed an economy in fuel of 37.2 per cent., and in water of 10.7 per cent., per car mile, in favor of the compound locomotive.

In December, 1893, and January, 1894, a series of tests was made in passenger service by Mr. L. B. Paxson, Superintendent of Motive Power and Rolling Equipment of the Philadelphia and Reading Railroad, of the compound "Columbia" type locomotive No. 694, and the single-expansion American type locomotive No. 1016.

These tests were conducted (1) to determine the difference of economy of two locomotives and (2) to ascertain if it were possible to use buckwheat or pea coal in high-speed passenger service. Separate tests were made with the locomotives burning egg, pea, and buckwheat coal.

The average steam pressure for the compound was 169.6 pounds, and for the single-expansion 152.9 pounds.

The course was between Camden and Atlantic City, a distance of 55.5 miles.

The results showed that when both locomotives burned egg coal, a saving was made in favor of the compound of 26.9 per cent. When both locomotives burned pea coal the saving in
favor of the compound was 27.3 per cent., and a comparison between the single-expansion locomotive burning egg coal and the compound burning pea coal still showed a saving of 6.9 per cent. in actual weight; but when the difference of cost is considered the saving would be 68.6 per cent. in favor of the compound. It was demonstrated by these tests that pea coal could be satisfactorily used on high-speed passenger service in compound locomotives only, and also that the compound locomotive would do better with pea coal as fuel than the single-expansion locomotive with egg coal.

![ATLANTIC TYPE LOCOMOTIVE, CHICAGO BURLINGTON & QUINCY RAILROAD.](image)

In August, 1894, a test was made in freight and passenger service by Mr. J. E. Fulton, Locomotive Superintendent of the Wellington and Manawatu Railway (a narrow-gauge road in New Zealand), of the ten-wheeled compound passenger locomotive No. 14, shown by the illustration on page 148, and the compound consolidation freight locomotive No. 13, the latter in competition with the single-expansion consolidation locomotive No. 12, of similar weight and dimensions.

The crucial test was on a section of the road where a grade of 1 to 100 occurred. This grade was three miles in length, and the compound ran it easily with 83 cars or 350 tons, exclusive of its own weight of 56 tons, at a rate of 6 miles an hour; the usual load for the company’s best locomotives of the single-expansion type on this grade being 45 cars or 250 tons.

The result of the test showed a saving in fuel with the compound locomotive of exactly 25 per cent., and the trip was made in quicker time than with the single-expansion.
In April, 1894, a series of tests was made on the Central Railroad of New Jersey, in passenger service, of the compound locomotive No. 450 of the American type, and the single-expansion passenger locomotive No. 455, of similar dimensions.

These tests were conducted by Mr. Russell E. Taylor; M. E., Mr. Chas. C. Kenyon, M. E., and Mr. Edward D. Mathey, M. E., a committee from Stevens Institute of Technology, the object being to ascertain comparatively (1) the evaporation from and at 212 deg. Fahrenheit per pound of coal, (2) the water per hour per horse-power, (3) the coal used per ton of total train mile, and (4) the action of the engines under various conditions.

The course was between Jersey City and Wayne Junction, a distance of 85.1 miles.

**SUBURBAN LOCOMOTIVE, LONG ISLAND RAILROAD.**

Two round trips were made with each locomotive. The average boiler pressure carried was for the compound 164.9 pounds, and for the single-expansion 157.5 pounds.

The general results obtained show a percentage in favor of the compound locomotive as follows:

- In coal consumed during test .............. 19.86 per cent.
- In water evaporated from and at 212° per pound of coal on run ...................... 18.7 per cent.
- In rate of combustion per sq. ft. of grate per hour during run ...................... 20.05 per cent.
- In tons of train hauled per mile per pound of coal ...................... 15.85 per cent.
The record of one ten-wheel compound and nine single-expansion locomotives of the same type, differing only in the construction of the cylinders, taken from the monthly performance sheets issued by Mr. John Mackenzie, Superintendent of Motive Power of the New York, Chicago and St. Louis Railroad, for nine months, from November, 1892, to July, 1893, gives an average consumption of fuel per mile run for the compound locomotive of 3.1 pounds, and for the single-expansion locomotive 4 pounds, making a total saving in favor of the compound locomotive of 22.5 per cent.

In October, 1896, a test was made in freight service, under the direction of Mr. John Hickey, Superintendent M. P. & R. S. of the Northern Pacific Railroad, and under the immediate supervision of Mr. W. B. Norton, Road Foreman of Engines, of a compound consolidation locomotive, No. 488, and a single-expansion consolidation locomotive, No. 492.

As originally built these locomotives were of the same size and general design, the single-expansion cylinders of No. 488 having been subsequently replaced by compound cylinders.
The test was made on the portion of the Northern Pacific Line between Leslie and the summit of the Cascade Mountains, a distance of 16.1 miles, on an average grade of 116 feet per mile.

Out of a number of trips run, three were selected as having all the conditions comparatively equal. These show an average consumption of coal by the compound locomotive of 2976 lbs., and by the single-expansion locomotive of 5521 lbs. The average water evaporation by the compound was 2622 gallons, and by the single-expansion 3759 gallons. The average load was 435 tons hauled by the compound and 430 tons hauled by the single-expansion.

The results show a saving in favor of the compound locomotive of forty-six per cent. in the consumption of fuel, and thirty per cent. in the evaporation.

The following table gives the actual running time for one trip made by locomotive No. 1028, with a train of five cars, July 1, 1898, on the Atlantic City Division of the Philadelphia and Reading Railway.

The locomotive is illustrated by the cut of No. 1027, on page 197, which is of same type and dimensions. It will be noted that a single mile was made in 41 seconds, which indicates a speed of 87.8 miles per hour. An average speed of 81.8 miles
per hour was maintained between mile-posts 48 and 3, a distance of 45 miles. This includes some of the heaviest grades on the division. For 36 miles, or from mile-post 39 to mile-post 3, the distance was covered at an average speed of 82.8 miles per hour.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Camden</td>
<td></td>
<td></td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>3 52</td>
<td>149</td>
<td>27</td>
<td>4 14</td>
<td>55</td>
</tr>
<tr>
<td>54</td>
<td>3 53</td>
<td>75</td>
<td>26</td>
<td>4 15</td>
<td>37</td>
</tr>
<tr>
<td>53</td>
<td>3 54</td>
<td>59</td>
<td>25</td>
<td>4 16</td>
<td>20</td>
</tr>
<tr>
<td>52</td>
<td>3 55</td>
<td>56</td>
<td>24</td>
<td>4 17</td>
<td>03</td>
</tr>
<tr>
<td>51</td>
<td>3 56</td>
<td>55</td>
<td>23</td>
<td>4 17</td>
<td>46</td>
</tr>
<tr>
<td>50</td>
<td>3 57</td>
<td>54</td>
<td>22</td>
<td>4 18</td>
<td>30</td>
</tr>
<tr>
<td>49</td>
<td>3 58</td>
<td>50</td>
<td>21</td>
<td>4 19</td>
<td>15</td>
</tr>
<tr>
<td>48</td>
<td>3 59</td>
<td>50</td>
<td>20</td>
<td>4 19</td>
<td>59</td>
</tr>
<tr>
<td>47</td>
<td>3 59</td>
<td>47</td>
<td>19</td>
<td>4 20</td>
<td>43</td>
</tr>
<tr>
<td>46</td>
<td>4 00</td>
<td>47</td>
<td>18</td>
<td>4 21</td>
<td>25</td>
</tr>
<tr>
<td>45</td>
<td>4 01</td>
<td>46</td>
<td>17</td>
<td>4 22</td>
<td>08</td>
</tr>
<tr>
<td>44</td>
<td>4 02</td>
<td>43</td>
<td>16</td>
<td>4 22</td>
<td>51</td>
</tr>
<tr>
<td>43</td>
<td>4 02</td>
<td>45</td>
<td>15</td>
<td>4 23</td>
<td>34</td>
</tr>
<tr>
<td>42</td>
<td>4 03</td>
<td>47</td>
<td>14</td>
<td>4 24</td>
<td>18</td>
</tr>
<tr>
<td>41</td>
<td>4 04</td>
<td>49</td>
<td>13</td>
<td>4 25</td>
<td>03</td>
</tr>
<tr>
<td>40</td>
<td>4 05</td>
<td>49</td>
<td>12</td>
<td>4 25</td>
<td>48</td>
</tr>
<tr>
<td>39</td>
<td>4 06</td>
<td>49</td>
<td>11</td>
<td>4 26</td>
<td>32</td>
</tr>
<tr>
<td>38</td>
<td>4 06</td>
<td>46</td>
<td>10</td>
<td>4 27</td>
<td>15</td>
</tr>
<tr>
<td>37</td>
<td>4 07</td>
<td>45</td>
<td>9</td>
<td>4 27</td>
<td>59</td>
</tr>
<tr>
<td>36</td>
<td>4 08</td>
<td>43</td>
<td>8</td>
<td>4 28</td>
<td>42</td>
</tr>
<tr>
<td>35</td>
<td>4 09</td>
<td>44</td>
<td>7</td>
<td>4 29</td>
<td>25</td>
</tr>
<tr>
<td>34</td>
<td>4 09</td>
<td>44</td>
<td>6</td>
<td>4 30</td>
<td>09</td>
</tr>
<tr>
<td>33</td>
<td>4 10</td>
<td>45</td>
<td>5</td>
<td>4 30</td>
<td>51</td>
</tr>
<tr>
<td>32</td>
<td>4 11</td>
<td>43</td>
<td>4</td>
<td>4 31</td>
<td>32</td>
</tr>
<tr>
<td>31</td>
<td>4 12</td>
<td>43</td>
<td>3</td>
<td>4 32</td>
<td>16</td>
</tr>
<tr>
<td>30</td>
<td>4 12</td>
<td>43</td>
<td>2</td>
<td>4 33</td>
<td>07</td>
</tr>
<tr>
<td>29</td>
<td>4 13</td>
<td>43</td>
<td>1</td>
<td>4 34</td>
<td>15</td>
</tr>
<tr>
<td>28</td>
<td>4 14</td>
<td>43</td>
<td>Atlantic City</td>
<td>4 35</td>
<td>17</td>
</tr>
</tbody>
</table>

Time, 45 minutes 17 seconds.

Complete detailed reports of the foregoing tests, with indicator diagrams, are on file in the office of the Baldwin Locomotive Works, and can be examined by any one interested.
LOCOMOTIVE DETAILS.
EACH locomotive has the builder’s number plate attached to sides of smoke box directly over steam chests, except in small engines of special designs, when it is placed on smoke box door, or in some other conspicuous position. This plate contains the name of the manufacturers, the consecutive construction number of the engine, and the year in which constructed.

In ordering parts, in all cases where it is possible to do so, this construction number should be given, and when this cannot be obtained, the original road number, class number, or name should be supplied. This information will assist in referring to original records and facilitate the work of renewals.

The locomotive details and code words herein given can be used with reference to either broad or narrow-gauge locomotives.
INSTRUCTIONS FOR CABLING.

The cable address is, "Baldwin, Philadelphia."

All code words relating to duplicate parts begin with the letter "E."

Each of the tables accompanying the following plates has in large heavy letters opposite the plate number a code word, the use of which indicates that all the parts shown on the plate are required; and each of the items has opposite it a code word in small heavy letters indicating that only that particular piece is needed.

In all cases it is understood that a set or enough for one locomotive will be sent unless specific instructions to the contrary are given.

On pages 231-239 a list will be found of duplicate parts in groups, such as are generally ordered, with a code word corresponding to each group.

In answering inquiries for prices, the cost is made for delivery f. o. b. vessel in Philadelphia or New York, unless otherwise indicated.

The construction or consecutive number of the locomotive should be used in cabling and in writing orders. This is shown on the builder's plates, which are generally on the smoke box above the cylinders. Code words corresponding to construction numbers will be found in the tables herewith (pages 213-221), which range from 1 to 25000 (from 1 to 1000 inclusive proceeding by units, and from 1000 to 25000 proceeding by thousands).

Words consisting of more than ten letters are counted as two words. When the name of a railway or firm embraces two or more words containing ten letters or less in all, they can be cabled as one: for instance, "Costarica Railway" (two words), meaning Costa Rica Railway.

It is a rule of all telegraph companies that in cabling, three figures count as one word. Therefore, any construction number can be cabled in two words: for instance, 13 975 (13975), which would be counted two words. Inasmuch, however, as figures are more apt to be improperly transmitted than words, a table has been prepared (see page 213) by the use of which construction numbers can still be given in two words and some of them in one, these words being less liable to misconstruction than the figures.
Messages should be written very plainly, so that there can be no doubt as to the word used, and no possibility of the division of one word into two.

Upon application a code word will be assigned, representing the name of any railroad company or firm desiring to do business by cable with the Baldwin Locomotive Works.

Example: The construction number 6000 would be one word, "Eenlobbig;" while 6020 would be "Eenlobbig Earthworms," and 12540 "Eensgezind Ecofora" ("Eensgezind" standing for 12000 and "Ecofora" for 540). 6020 could also be 6 020, and 12540 be 12 540; but the word method is preferable.

Example: If it is desired to cable for a boiler complete, as shown on Plate I, for engine 13978, to be shipped by steamer to Havana, Cuba, the message would read as follows (the signature should be the name of the company ordering or its code word):

Havana, January 10, 1895.

Baldwin, Philadelphia.

Eerekrans
Ehrenruf
Eerewoord
Eensklaps
Eenbladig

(Signed) (Code name or actual name of Company.)

Translation:

Havana, January 10, 1895.

Baldwin, Philadelphia.

Eerekrans . . Please ship by steamer as soon as possible duplicate parts covered by code word
Ehrenruf . . Boiler and all parts on Plate 1.
Eerewoord . . For one locomotive, construction number
Eensklaps \{ 13978.
Eenbladig \} (Name of Company.)
But if a set of tubes were wanted, the message would read:

HAVANA, January 10, 1895.

Baldwin, Philadelphia.

Eerekrans
Ehrgeizig
Eerewoord
Eensklaps
Eenbladig

(Signed) (Code name or actual name of Company.)

Translation:

HAVANA, January 10, 1895.

Baldwin, Philadelphia.

Eerekrans . Please ship by steamer as soon as possible duplicate parts covered by code word
Ehrgeizig . Boiler tubes.
Eerewoord . For one locomotive, construction number
Eensklaps 
\[\text{\#} 13978.\]
Eenbladig 

(Name of Company.)

If three sets of tubes were wanted for the same locomotive, or for locomotives of the same dimensions, the message would read:

HAVANA, January 10, 1895.

Baldwin, Philadelphia.

Eerekrans
Ehrgeizig
Eergierig
Eensklaps
Eenbladig

(Signed) (Code name or actual name of Company.)
Translation:

Havana, January 10, 1895.

Baldwin, Philadelphia:

Eerekrans . . Please ship by steamer as soon as possible duplicate parts covered by code word

Ehrgeizig . . Boiler tubes.

Eergierig . . For three locomotives, construction number

Eensklaps . \{ 13978.

Eenbladig . \} (Name of Company.)

To order a pair of cylinders from Rio de Janeiro, Brazil, with parts attached, a message would read:

Rio, March 1, 1895.

Baldwin, Philadelphia.

Eerekroon
Effricatum (see page 229.)
Eensdeels
Eddaic

(Signed) (Code name or actual name of Company.)

Translation:

Rio, March 1, 1895.

Baldwin, Philadelphia.

Eerekroon . . Please ship by steamer as soon as possible duplicate parts covered by code word (see *) for locomotive, construction number (see **).

Effricatum . . * 1 pair cylinders with heads, covers, chests, caps, casings, glands, valves, yokes and pistons, painted and varnished.

Eensdeels . \} **1743.

Eddaic . \} (Name of Company.)
A cable message from Yokohama, Japan, for a crosshead for left side of locomotive 14126, would read as follows:

**YOKOHAMA, March 22, 1895.**

**BALDWIN, Philadelphia.**

Eeredienst
Eigilwich
Eeretomben
Eensnarig
Eboueuses

(Signed) (Code name or actual name of Company.)

Translation:

**YOKOHAMA, March 22, 1895.**

**BALDWIN, Philadelphia.**

Eeredienst . . Please ship by quickest freight route as soon as possible duplicate parts covered by code word

Eigilwich . . Crosshead.
Eeretomben . For left hand side of one locomotive, construction number
Eensnarig .}
Eboueuses .} 14126.

(Name of Company.)

**RIO, March 1, 1895.**

**BALDWIN, Philadelphia.**

Eerekrans
Eilamides
Eeresabels
Eenschalig
Ebaucherias
Eerstdaags

(Signed) (Code name or actual name of Company.)
Translation:

Baldwin, Philadelphia.

Rio, March 1, 1895.

Eerekrans. Please ship by steamer as soon as possible duplicate parts covered by code word

Eilamides. Eccentric strap.

Eeresabels. For right hand side of one locomotive, construction number

Eenschalig. 10055.

Ebaucheras.

Eerstdaags. Backward motion.

(Name of Company.)
### Cable Code Numbers

| 1 Eachwhere | 35 Ebahii | 69 Ebdomada |
| 2 Eactarius | 36 Ebalaco || 70 Ebelians |
| 3 Eadbert  | 37 Ebalette || 71 Ebenaceo |
| 4 Eadburge | 38 Ebanacee | 72 Ebenastre |
| 5 Eadwin   | 39 Ebanista | 73 Ebenbild |
| 6 Eager    | 40 Ebanizar | 74 Ebeneous |
| 7 Eagerly  | 41 Ebankers | 75 Ebenizer |
| 8 Eagerness| 42 Ebano || 76 Ebenfalls |
| 9 Eagrass  | 43 Ebanoyer | 77 Ebenheit |
| 10 Eanred  | 44 Ebaque || 78 Ebeni  |
| 11 Eapse   | 45 Ebarbement|| 79 Ebenier |
| 12 Earinus  | 46 Ebarbeuse || 80 Ebenistes |
| 13 Earshrift| 47 Ebarboir | 81 Ebenmass |
| 14 Earthiness| 48 Ebarou || 82 Ebenoxyle |
| 15 Earthling| 49 Ebattons  | 83 Ebenrecht |
| 16 Earthly | 50 Ebahttriez | 84 Ebensohle |
| 17 Earthquake| 51 Ebattron || 85 Ebenspiel |
| 18 Earthward | 52 Ebattu || 86 Ebenuz  |
| 19 Earthwork | 53 Ebaubi || 87 Ebenwage |
| 20 Earthworms | 54 Ebauchage || 88 Eberesche |
| 21 Earwig | 55 Ebaucheras | 89 Ebergement |
| 22 Earwort  | 56 Ebauchiez | 90 Eberhard |
| 23 Easeful | 57 Ebauchoir | 91 Eberhirsch |
| 24 Easels | 58 Ebbeanker | 92 Eberlue |
| 25 Easily  | 59 Ebbeboom | 93 Eberulf |
| 26 Easiness | 60 Ebbene  | 94 Ebetazione |
| 27 Easmium | 61 Ebbehout  | 95 Ebetement |
| 28 Easterling | 62 Ebbero  | 96 Ebeto |
| 29 Easterly | 63 Ebbestrom | 97 Ebeurrer |
| 30 Eastward | 64 Ebbezeit | 98 Ebeylieres |}

| 31 Eatable | 65 Ebbing || 99 Ebiasaph |
| 32 Etage    | 66 Ebbrezza | 100 Ebionisme |
| 33 Eauzan   | 67 Ebbrieta | 101 Ebiscum |
| 34 Eavagier | 68 Ebbioso | 102 Ebiselo |
103 Eblana 144 Ebraizzano 185 Ebruiter
104 Eblandior 145 Ebraizzare 186 Ebruiteras
105 Eblanditus 146 Ebraizzava 187 Ebruitiez
106 Eblanine 147 Ebraizzo 188 Ebruitons
107 Eblouimes 148 Ebrancadas 189 Ebrulpho
108 Eblourir 149 Ebrancado 190 Ebucheter
109 Eblouiras 150 Ebranchait 191 Ebude
110 Eblouired 151 Ebranchiez 192 Ebulinus
111 Eblouiron 152 Ebranchons 193 Ebulliate
112 Eblouisses 153 Ebranlait 194 Ebullicao
113 Eboda 154 Ebranler 195 Ebulliency
114 Ebonist 155 Ebranliez 196 Ebullition
115 Ebonite 156 Ebranlions 197 Ebulo
116 Ebonized 157 Ebrasure 198 Eburacum
117 Eboraci 158 Ebreche 199 Eburatus
118 Eboracum 159 Ebrenueur 200 Eburinorum
119 Eborarios 160 Ebría 201 Eburiphore
120 Eborensre 161 Ebriacus 202 Eburnation
121 Eborgnage 162 Ebriation 203 Eburnean
122 Eboribus 163 Ebriativo 204 Eburneos
123 Ebosia 164 Ebriato 205 Eburninae
124 EboUAGE 165 Ebriavisti 206 Eburobriga
125 Eboueur 166 Ebriedad 207 Eburodunum
126 Eboueuses 167 Ebrietas 208 Eburon
127 Ebouffer 168 Ebriety 209 Eburones
128 Ebouger 169 Ebriex 210 Eburovices
129 Eboüli 170 Ebrillade 211 Ebusus
130 Eboulais 171 Ebrios 212 Ecabochage
131 Eboulee 172 Ebriosidad 213 Ecabocher
132 Eboülement 173 Ebriositas 214 Ecachement
133 Ebouleront 174 Ebriosos 215 Ecaffer
134 Ebouleux 175 Ebrious 216 Ecafignon
135 Ebouquerter 176 Ebriulatus 217 Ecaflote
136 Ebouriff 177 Ebrodunum 218 Ecagne
137 Ebouisine 178 Ebroin 219 Ecaillage
138 Ebouter 179 Ebromagi 220 Ecaillaire
139 Ebouture 180 Ebromagus 221 Ecaille
140 Ebraiche 181 Ebrondeur 222 Ecaillette
141 Ebraico 182 Ebrosser 223 Ecalkarate
142 Ebraismo 183 Ebrouait 224 Ecaler
143 Ebraisoir 184 Ebrouement 225 Ecalisseeur
| 349 | Echaudoir     | 390 | Echinite          | 431 | Echoueriez        |
| 350 | Echauffer    | 391 | Echinocere       | 432 | Echoueront        |
| 351 | Echauffure   | 392 | Echinoderm       | 433 | Echouiez          |
| 352 | Echaulant    | 393 | Echinodore       | 434 | Echouons          |
| 353 | Echaux       | 394 | Echinogale       | 435 | Echrefite         |
| 354 | Echazones    | 395 | Echinoxyne       | 436 | Echsenbrut        |
| 355 | Echeable     | 396 | Echinoide        | 437 | Echsenei          |
| 356 | Echeancier   | 397 | Echinome         | 438 | Echtbreken        |
| 357 | Echebulus    | 398 | Echinomys        | 439 | Echtbreuk         |
| 358 | Echelea      | 399 | Echinopo         | 440 | Echtbeband        |
| 359 | Echecrates   | 400 | Echinopode       | 441 | Echtebed          |
| 360 | Echecs       | 401 | Echinorhin       | 442 | Echtelijk         |
| 361 | Echedamia    | 402 | Echinooza        | 443 | Echtgareel        |
| 362 | Echeggia     | 403 | Echinulate       | 444 | Echtgenoot        |
| 363 | Echeggiano   | 404 | Echinus          | 445 | Echtieht          |
| 364 | Echeggiare   | 405 | Echinussa        | 446 | Echtibre          |
| 365 | Echeggiava   | 406 | Echionussides    | 447 | Echtig            |
| 366 | Echelades    | 407 | Echiopsis        | 448 | Echtkoets         |
| 367 | Echelaos     | 408 | Echiquete        | 449 | Echtwort          |
| 368 | Echelidae    | 409 | Echine           | 450 | Echura            |
| 369 | Echelonner   | 410 | Echiurede        | 451 | Ecidine           |
| 370 | Echeneide    | 411 | Echkendji        | 452 | Ecimable          |
| 371 | Echeneidis   | 412 | Echmagoras       | 453 | Eckard            |
| 372 | Echeniller   | 413 | Echnemos         | 454 | Eckband           |
| 373 | Ecephron     | 414 | Echoes           | 455 | Eckbert           |
| 374 | Ecepolis     | 415 | Echoicus         | 456 | Eckehard          |
| 375 | Echeveria    | 416 | Echoing          | 457 | Eckelhait         |
| 376 | Echevinage   | 417 | Echome           | 458 | Eckeln            |
| 377 | Echidna      | 418 | Echometer        | 459 | Eckenhalm         |
| 378 | Echidnine    | 419 | Echometria       | 460 | Eckenzahl         |
| 379 | Echidorus    | 420 | Echometro        | 461 | Eckerganz         |
| 380 | Echignole    | 421 | Echonele         | 462 | Eckermast         |
| 381 | Echimyd      | 422 | Echopolus        | 463 | Eckhaus           |
| 382 | Echimyside   | 423 | Echoppage        | 464 | Eckkegel          |
| 383 | Echinacee    | 424 | Echoppe          | 465 | Ecklace           |
| 384 | Echinaria    | 425 | Echoton          | 466 | Ecklonie          |
| 385 | Echinated    | 426 | Echouage         | 467 | Eckplatz          |
| 386 | Echinidae    | 427 | Echouais         | 468 | Ecksaal           |
| 387 | Echinidans   | 428 | Echouasses       | 469 | Ecksaeulen        |
| 388 | Echinipede   | 429 | Echouer          | 470 | Eckschuh          |
| 389 | Echinital    | 430 | Echouerais       | 471 | Eckstamm          |
| 472 Eckstein | 513 Eclipsons | 554 Economico |
| 473 Eckthor   | 514 Eclipticus | 555 Economique |
| 474 Ecktisch  | 515 Eclissage  | 556 Economist  |
| 475 Eckzahn   | 516 Eclissammo | 557 Economizar |
| 476 Eclactisme| 517 Eclissando | 558 Economize  |
| 477 Eclaffer  | 518 Eclissassi | 559 Econtrario |
| 478 Eclair    | 519 Eclissava  | 560 Econverso  |
| 479 Eclairage | 520 Eclisser   | 561 Ecoper     |
| 480 Eclairais | 521 Eclisso    | 562 Ecoperche  |
| 481 Eclairci  | 522 Eclittica  | 563 Ecoquer    |
| 482 Eclaircise| 523 Eclogarius | 564 Ecocage    |
| 483 Eclairons | 524 Eclogarum  | 565 Ecorchant  |
| 484 Eclampsy  | 525 Eclopper   | 566 Ecorchasse |
| 485 Eclanche  | 526 Eclore     | 567 Ecorcheler |
| 486 Eclandre  | 527 Ecloses    | 568 Ecorchiez  |
| 487 Eclapsia  | 528 Eclosion   | 569 Ecorcons   |
| 488 Eclapsible| 529 Eclosa    | 570 Ecornifle  |
| 489 Eclatable | 530 Eclusement | 571 Ecostain   |
| 490 Eclatais  | 531 Ecmatryie  | 572 Ecostaisy  |
| 491 Eclateriez| 532 Ecmelia    | 573 Ecosteneux |
| 492 Eclatons  | 533 Ecnebias   | 574 Ecotado    |
| 493 Ecliche   | 534 Economus   | 575 Ecotant    |
| 494 Eclecticos| 535 Ecobuer    | 576 Ecotard    |
| 495 Eclecticique| 536 Ecocide   | 577 Ecoulailles|
| 496. Eclectiser| 537 Ecodie    | 578 Ecouanette |
| 497 Eclectisme| 538 Ecoeurant  | 579 Ecouchures |
| 498 Eclectizar| 539 Ecoeurer   | 580 Ecoulard   |
| 499 Eclegma   | 540 Ecofora    | 581 Ecoulera   |
| 500 Eclespiss | 541 Ecofrai    | 582 Ecoulerait |
| 501 Ecclesiarca| 542 Ecoica     | 583 Ecourgee   |
| 502 Ecclettismo| 543 Ecoicos   | 584 Ecourgeon  |
| 503 Eclidon   | 544 Ecoincon   | 585 Ecourtant  |
| 504 Eclogmata | 545 Ecolage    | 586 Ecoussage  |
| 505 Eclogmatis| 546 Ecole      | 587 Ecoutames  |
| 506 Eclogmatum| 547 Ecolerer   | 588 Ecoutasses |
| 507 Eclingure | 548 Ecoliens   | 589 Ecouteraes |
| 508 Eclipsable| 549 Eometria   | 590 Ecouterons |
| 509 Eclipsais | 550 Eometro    | 591 Ecouteur   |
| 510 Eclipsar  | 551 Eonduirai  | 592 Ecoutille  |
| 511 Eclipsaron| 552 Economat   | 593 Ecoutillon |
| 512 Eclipse   | 553 Economicas | 594 Ecoutoir   |
595 Ecouverte | 636 Ecremer | 677 Ectypo
596 Ecphasis | 637 Ecremillon | 678 Ectobie
597 Ecphylysis | 638 Ecremoire | 679 Ectoblast
598 Ecphoneme | 639 Ecrevisse | 680 Ectocarpe
599 Ecphonesis | 640 Ecrhexis | 681 Ectocyste
600 Ecphora | 641 Ecriames | 682 Ectoderme
601 Ecphorarum | 642 Ecriteront | 683 Ectogramma
602 Ecphoris | 643 Ecrille | 684 Ectolitro
603 Ecpheorome | 644 Ecrions | 685 Ectometro
604 Ecphractic | 645 Ecrisse | 686 Ectonstero
605 Ecphraste | 646 Ecriveau | 687 Ectophage
606 Ecphyma | 647 Ecrimol | 688 Ectopagia
607 Ecphymote | 648 Ecrithoire | 689 Ectophyte
608 Ecphyshe | 649 Ecriturier | 690 Ectopia
609 Ecphysese | 650 Ecrivaille | 691 Ectopogono
610 Ecpiema | 651 Ecrivimes | 692 Ectopones
611 Ecpiesme | 652 Ecroee | 693 Ectosarc
612 Ecpleope | 653 Ecroistre | 694 Ectosmie
613 Ecplerome | 654 Ecrouellet | 695 Ectozoa
614 Ecplessia | 655 Ecrouir | 696 Ectrogenie
615 Ecplexie | 656 Ecrouituge | 697 Ectromata
616 Ecnpoe | 657 Ecrysie | 698 Ectromatis
617 Ecpyeme | 658 Ecsarcome | 699 Ectrome
618 Ecypysis | 659 Ecstacy | 700 Ectroparum
619 Ecpyetique | 660 Ecstasize | 701 Ectropical
620 Ecpyrosis | 661 Ecstatic | 702 Ectropio
621 Ecqui | 662 Ecstactical | 703 Ectrotico
622 Ecquod | 663 Ectadion | 704 Ectrotique
623 Ecrobouir | 664 Ectatique | 705 Ectylotic
624 Ecrache | 665 Ectatops | 706 Ectypal
625 Ecraigne | 666 Ectenes | 707 Ectyp	
626 Ecrainier | 667 Ectese | 708 Ectypique
627 Ecrapette | 668 Ecthesien | 709 Ectyporum
628 Ecrasable | 669 Echtlimme | 710 Ecuable
629 Ecrasais | 670 Echtlipe | 711 Ecuacion
630 Ecraser | 671 Echtlipis | 712 Ecuanteur
631 Ecraserais | 672 Ecthyama | 713 Ecubier
632 Ecrasilye | 673 Ecthyose | 714 Ecueil
633 Ecrasiez | 674 Ecthyosis | 715 Ecuauge
634 Ecrasure | 675 Ectilotici | 716 Ecuilo
635 Ecremaison | 676 Ectimosi | 717 Ecumais
| 718 | Ecumant       | 759 | Edelfink       | 800 | Edentamus          |
| 719 | Ecumenical    | 760 | Edelsch         | 801 | Edentation         |
| 720 | Ecumenico     | 761 | Edelfrau        | 802 | Edento             |
| 721 | Ecumeresse    | 762 | Edelfuchs       | 803 | Edentula           |
| 722 | Ecumeront     | 763 | Edelgarbe       | 804 | Edentulus          |
| 723 | Ecumeux       | 764 | Edelhengst      | 805 | Edeopalmo          |
| 724 | Ecumions      | 765 | Edelhof         | 806 | Edepoe             |
| 725 | Ecumoire      | 766 | Edelknabe       | 807 | Edera              |
| 726 | Ecunemica     | 767 | Edelknecht      | 808 | Ederaceo           |
| 727 | Ecunemicos    | 768 | Edelkrebs       | 809 | Ederaceus          |
| 728 | Ecurorea      | 769 | Edellehen       | 810 | Ederato            |
| 729 | Ecuroeos      | 770 | Edelmann        | 811 | Ederoso            |
| 730 | Ecureuil      | 771 | Edelmarder      | 812 | Edesio             |
| 731 | Ecusson       | 772 | Edelmass        | 813 | Edesseno           |
| 732 | Ecussonne     | 773 | Edelmoedig      | 814 | Edessenus          |
| 733 | Ecvolorum     | 774 | Edelmogend      | 815 | Edesside           |
| 734 | Ecvolus       | 775 | Edelmuth        | 816 | Edetana            |
| 735 | Eczematous    | 776 | Edelopal        | 817 | Edetanos           |
| 736 | Edacidade     | 777 | Edelraut        | 818 | Edgar              |
| 737 | Edacious      | 778 | Edelreis        | 819 | Edgeless           |
| 738 | Edaciously    | 779 | Edelrose        | 820 | Edgewise           |
| 739 | Edacissimo    | 780 | Edelschoen      | 821 | Edgythe            |
| 740 | Edacitatis    | 781 | Edelsinn        | 822 | Edharz             |
| 741 | Edacite       | 782 | Edelsinnig      | 823 | Edhemite           |
| 742 | Edaphodont    | 783 | Edelstahl       | 824 | Edibility          |
| 743 | Edaic         | 784 | Edelstolz       | 825 | Edible             |
| 744 | Eddas         | 785 | Edelthat        | 826 | Ediblesness        |
| 745 | Eddered       | 786 | Edelthier       | 827 | Edicaria           |
| 746 | Eddering      | 787 | Edelvrouw       | 828 | Edicendum          |
| 747 | Eddoes        | 788 | Edelweiss       | 829 | Edichio            |
| 748 | Edealogia     | 789 | Edeomatico      | 830 | Edicola            |
| 749 | Edeatrois     | 790 | Edeamatoso      | 831 | Edictabam          |
| 750 | Edecan        | 791 | Edeamatus       | 832 | Edictabis          |
| 751 | Edecanes      | 792 | Edemera         | 833 | Edictalium         |
| 752 | Edecimamus    | 793 | Edenique        | 834 | Edictamus          |
| 753 | Edecimatum    | 794 | Edenisch        | 835 | Edictarem          |
| 754 | Edecimavi     | 795 | Edenize         | 836 | Edictavi           |
| 755 | Edelaardig    | 796 | Edenizing       | 837 | Edictione          |
| 756 | Edeldame      | 797 | Edenuine        | 838 | Edictionis         |
| 757 | Edelerde      | 798 | Edental         | 839 | Edictorum          |
| 758 | Edelfest      | 799 | Edentalous      | 840 | Edicule            |
| 964 | Edzard       | 984 | Eendenkooi | 6,000 | Eenlobbig    |
| 965 | Eedbrekers  | 985 | Eendennest  | 7,000 | Eenoog      |
| 966 | Eedbreuk    | 986 | Eendenroer  | 8,000 | Eenooigig   |
| 967 | Eedgespan   | 987 | Eender      | 9,000 | Eenrijm     |
| 968 | Eegaas      | 988 | Eendeveder  | 10,000 | Eenschalig |
| 969 | Eekhakker   | 989 | Eendjes     | 11,000 | Eensdeels  |
| 970 | Eekhandel   | 990 | Eendracht   | 12,000 | Eensgezind |
| 971 | Eekhoren    | 991 | Eendvogels  | 13,000 | Eensklaps  |
| 972 | Eelbuck     | 992 | Eengrezipig | 14,000 | Eensnarig  |
| 973 | Eelpot      | 993 | Eenhandig   | 15,000 | Eenspan    |
| 974 | Eelspear    | 994 | Eenheid     | 16,000 | Eenstemmig |
| 975 | Eeltachtig  | 995 | Eenhelmig   | 17,000 | Eenstijlig |
| 976 | Eelterig    | 996 | Eenhoekig   | 18,000 | Eenvakkig  |
| 977 | Eeltzweer   | 997 | Eenhoofdig  | 19,000 | Eenvervig  |
| 978 | Eenbladig   | 998 | Eenhoorn    | 20,000 | Eenvinnig  |
| 979 | Eenbloemig  | 999 | Eenhoornig  | 21,000 | Eenvoetig  |
| 980 | Eendebout   | 1,000 | Eenhuizig  | 22,000 | Eenvoud    |
| 981 | Eendenei    | 2,000 | Eenigerlei | 23,000 | Eenvoudig  |
| 982 | Eendenhok   | 3,000 | Eeniglijk  | 24,000 | Eenwijvig  |
| 983 | Eendenkom   | 4,000 | Eenkennig  | 25,000 | Eenzaam    |
|      |             | 5,000 | Eenkleurig |         |             |
USEFUL SENTENCES FOR CABLING FOR
PARTS OF LOCOMOTIVES.

Eenzelvig . . At what price and how soon can you ship duplicate
parts covered by code word............................?

Eenzijdig . . How soon can you ship duplicate parts covered by
code word.................................?

Eeotomous . . Please ship by express as soon as possible duplicate
parts covered by code word..........................

Eerambt . . Please ship by express as soon as possible duplicate
parts covered by code word..........................for
locomotive, construction number......................

Eerbetoon . . Please ship by freight as soon as possible duplicate
parts covered by code word...........................

Eereblijk . . Please ship by freight as soon as possible duplicate
parts covered by code word..........................for
locomotive, construction number......................

Eereboog . . Please ship overland as soon as possible duplicate
parts covered by code word...........................

Eeredegen . . Please ship overland as soon as possible duplicate
parts covered by code word..........................for
locomotive, construction number......................

Eeredienst . . Please ship by quickest freight route as soon as pos-
sible duplicate parts covered by code word ...........

Eeregraf . . Please ship by quickest freight route as soon as pos-
sible duplicate parts covered by code word
............................. for locomotive, construction num-
ber ...................................................

Eerekrans . . Please ship by steamer as soon as possible duplicate
parts covered by code word..........................

Eerekroon . . Please ship by steamer as soon as possible duplicate
parts covered by code word.......................... for
locomotive, construction number......................

Eeremantel . . Please ship by sailing vessel as soon as possible dupli-
cate parts covered by code word......................
Eereplaats . Please ship by sailing vessel as soon as possible duplicate parts covered by code word................. for locomotive, construction number.................

Eerepoort . Please ship by steamer as soon as possible duplicate parts to the value of $......................

Eerepost . Please ship by steamer as soon as possible duplicate parts to the value of $......................for locomotive, construction number.................

Eereposten . Please ship by sailing vessel as soon as possible duplicate parts to the value of $......................

Eereprijs . Please ship by sailing vessel as soon as possible duplicate parts to the value of $......................for locomotive, construction number.................

Eeresabels . For right hand side of one locomotive, construction number......................

Eereschot . For right hand side of two locomotives, construction number......................

Eerestoel . For right hand side of three locomotives, construction number......................

Eeretempel . For right hand side of four locomotives, construction number......................

Eeretitels . For right hand side of five locomotives, construction number......................

Eeretomboen . For left hand side of one locomotive, construction number......................

Eeretrap . For left hand side of two locomotives, construction number......................

Eerewacht . For left hand side of three locomotives, construction number......................

Eerewapen . For left hand side of four locomotives, construction number......................

Eerewijn . For left hand side of five locomotives, construction number......................

Eerewoord . For one locomotive, construction number......................

Eergevoel . For two locomotives, construction number......................

Eergierig . For three locomotives, construction number......................

Eerlijk . For four locomotives, construction number......................

Eerlijker . For five locomotives, construction number......................

Eerloozer . For six locomotives, construction number......................

Eermetaal . For seven locomotives, construction number......................

Eernamen . For eight locomotives, construction number......................
Eerpenning. . For nine locomotives, construction number.
Eerroof . . For ten locomotives, construction number.
Eerroovend . Hold order of until you receive further instructions.
Eershalve . . Forward motion.
Eerstdaags . . Backward motion.
Eertijds .
Eervol .
Eervoller .
Eerwaarde .
Eerwaardig .
Eerzamer .
Eerzucht .
Eerzuchtig .
Eesting .
Eestmout .
Eetbak .
Eethuis .
Eethuizen .
Eetion .
Eetionem .
Eetkamers .
Eetlepels .
Eetlust .
Eetmalen .
Eetplaats .
Eetregel .
Eetsters .
Eettafel .
Eetwaar .
Eetzaal .
Eeuwen .
Eeuwenoud .
Eeuwfeest .
Eeuwjaar .
Eeuwspel .
Eeuwzang .
Eeuwzangen .
Efantel .
Efaufile .
Efectuado .
Efectuamos
Efectuaron
Efectuases
Efectueis
Efedra
Efemerides
Efemerie
Efesias
Efesio
Efesite
Efetico
Effable
Efficable
Effacage
Effacais
Effacasses
Effacerais
Effaceriez
Effacerons
Effacest
Effacing
Effacons
Effaecata
Effaecatus
Effaner
Effanures
Effarcimus
Effario
Effarciunt
Effarement
Effarvatte
Effatio
Effatione
Effatorum
Effauce
Effaumer
Effeccao
Effecerim
Effecissem
Effectible
Effectif
Effectione  
Effectivo  
Effectivus  
Effectless  
Effectrix  
Effectuais  
Effectuar  
Effectuose  
Effecundo  
Effiancse  
Effeito  
Effeituoso  
Effelure  
Effeminar  
Effeminava  
Effeminize  
Effendi  
Effenende  
Effenheid  
Effening  
Efferascis  
Efferasco  
Efferator  
Efferatus  
Efferous  
Effersimus  
Effersist  
Effervens  
Efferveo  
Effervesce  
Effestria  
Effestuer  
Effete  
Effettore  
Effettrice  
Effettuato  
Effettuavi  
Effeuiller  
Effezione  
Efficacia  
Efficaz
Efficiency
Efficient
Efficienza
Efficta
Effectorum
Effictum
Effierced
Effiercing
Effigiado
Effigiar
Effigiasi
Effigiava
Effigie
Effigierai
Effiloche
Effiloquer
Effimero
Effindere
Efflagitas
Efflagito
Efflammans
Efflanque
Efflation
Efflatos
Effleurais
Effleure
Efflevisti
Efflictim
Effloreo
Effloremus
Effloresce
Efflorui
Efflower
Effluencia
Effluente
Effluescis
Effluivial
Effluvio
Effluvioso
Effluxed
Effluxing
Effluxorum
Effocare
Effoderunt
Effodimus
Effodisti
Effoedis
Effoedo
Effondrait
Effondront
Effor
Efforcais
Efforcant
Efforting
Efforcions
Efforeria
Efformed
Efformier
Effortless
Effossioni
Effossum
GROUPS OF DUPLICATE PARTS WITH
CODE WORDS.

[In some cases it will be more convenient to order parts by using these group
words; in others by a reference to the plates. See index (page 429) to find part
needed.]

Effouage . . . 1 Boiler with Tubes, Double Cone, Dry Pipe, Throttle
work complete, including Stuffing Box and
Gland, Dome Cap and Safety Valves, Smoke
Box, Front and Door, Fire Door with Liner and
Frame and Cleaning Plugs, tested and primed.

Effoueiel . . . 1 Boiler with Tubes and Cleaning Plugs only, tested
and primed.

Effractor . . . 1 Fire Box.

Effracture . . . 1 Set Boiler Tubes.

Effrange . . . 1 Set Boiler Tube Ferrules.

Effrayable . . . 1 Double Cone.

Effrayeur . . . 1 Set Steam Pipes.

Effrayeras . . . 1 Throttle Valve, Box, Pipe, Elbow, Crank, and
Rod.

Effrayiez . . . 1 Smoke Box Front and Door.

Effrayons . . . 1 Fire Door with Frame and Liner.

Effreiment . . . 1 Set Cleaning Plugs.

Effrenatio . . . 1 Set Fusible Plugs.

Effrenatus . . . 1 Set Boiler Lagging.

Effrenibus . . . 1 Set Boiler Jacket.

Effrenis . . . 1 Set Boiler Jacket Bands.

Effricare . . . 1 Set Safety Valves, complete.

Effricatum . . . 1 Pair Cylinders with Heads, Covers, Chests, Caps,
Casings, Glands, Valves, Yokes and Pistons,
painted and varnished.

Effrico . . . . 1 Pair Finished Cylinders, bolted together, without
any fittings.

Effrique . . . . 1 Set Front Cylinder Heads.

Effriter . . . . 1 Set Back Cylinder Heads.

Effrixisti . . . . 1 Set Front Cylinder Covers.

Effroisser . . . . 1 Set Back Cylinder Covers.

Effruitant . . . . 1 Set Cylinder Glands and Bottom Rings.
**Effrutico**...1 Set Metallic Packing complete, for Piston Rods and Valve Stems.

**Effugio**...1 Set Composition Rings for Metallic Packing of Piston Rods and Valve Stems.

**Effugisti**...1 Set Cylinder Casings.

**Effugitos**...1 Set Steam Chests.

**Effugiunt**...1 Set Steam Chest Caps or Lids.

**Effulcrate**...1 Set Steam Chest Glands and Bottom Rings.

**Effulge**...1 Set Steam Chest Casings.

**Effulgence**...1 Set Steam Chest Casing Covers.

**Effulgent**...1 Set Steam Chest Valves.

**Effulgetis**...1 Set Steam Chest Valve Yokes.

**Effulsio**...1 Set Steam Chest Relief Valves.

**Effulsioni**...1 Set Pistons with Rods and Packing.

**Effultorum**...1 Set Piston Rods.

**Effultus**...1 Set Piston Packing.

**Effumable**...1 Pair Cylinders with Heads, Covers, Casings, Valves, Stems, Pistons, Metallic Piston Rod and Valve Stem Packing, complete (Vauchain Compound System).

**Effumant**...1 Pair Finished Cylinders with Bushings, bolted together, but without other fittings (Vauchain Compound System).

**Effumigare**...1 Set Front Cylinder Heads, High Pressure (Vauchain Compound System).

**Effuming**...1 Set Back Cylinder Heads, High Pressure (Vauchain Compound System).

**Effundica**...1 Set Front Cylinder Head Casing Covers, High Pressure (Vauchain Compound System).

**Effundir**...1 Set Back Cylinder Head Casing Covers, High Pressure (Vauchain Compound System).

**Effundo**...1 Set Front Cylinder Heads, Low Pressure (Vauchain Compound System).

**Effusion**...1 Set Back Cylinder Heads, Low Pressure (Vauchain Compound System).

**Effusive**...1 Set Front Cylinder Head Casing Covers, Low Pressure (Vauchain Compound System).

**Effusively**...1 Set Back Cylinder Head Casing Covers, Low Pressure (Vauchain Compound System).

**Effusoris**...1 Set Front Valve Chamber Heads (Vauchain Compound System).
Effusorum . . . 1 Set Back Valve Chamber heads (Vauclain Compound System).

Effuticius . . . 1 Set Front Valve Chamber Head Casing Covers (Vauclain Compound System).

Effutile . . . . 1 Set Back Valve Chamber Head Casing Covers (Vauclain Compound System).

Effutilis . . . . 1 Set Valve Chamber Bushings (Vauclain Compound System).

Effutilium . . . 1 Set Main Piston Valves with Rings (Vauclain Compound System).

Eflalte . . . . 1 Set Main Piston Valves with Rings and Stems (Vauclain Compound System).

Eficiencia . . . 1 Set Main Piston Valve Rings (Vauclain Compound System).

Efigies . . . . 1 Set Pistons with Rods and Packing, High Pressure (Vauclain Compound System).

Eflagelle . . . . 1 Set Pistons with Rods and Packing, Low Pressure (Vauclain Compound System).

Efourceau . . . 1 Set Piston Packing Rings, High Pressure (Vauclain Compound System).

Efraimo . . . . 1 Set Piston Packing Rings, Low Pressure (Vauclain Compound System).

Efusal . . . . 1 Set Piston Rods (Vauclain Compound System).

Egagre . . . . 2 Starting Valves (Vauclain Compound System).

Egagropilo . . 4 Cylinder Cocks (Vauclain Compound System).

Egailler . . . . 1 Set Cylinder Relief Valves (Vauclain Compound System).

Egalement . . . 1 Set Frames without Fittings.

Egalisage . . . 1 Set Frame Front Rails.

Egalisier . . . 1 Set Frame Pedestal Caps.

Egalisersas . . 1 Set Pedestal Wedges.

Egalisons . . . 1 Set Pedestal Wedge Bolts.

Egalitaire . . . 1 Set Pedestal Gibs.

Egalite . . . . 1 Set Driving Wheels Complete, on Axles with Eccentrics, Eccentric Straps, and Boxes, painted and varnished.

Egancette . . . 1 Set Driving Tires.

Egarerais . . . 1 Set Wrist Pins.

Egareriez . . . 1 Set Driving Axles.

Egareront . . . 1 Set Eccentrics.

Egariez . . . . 1 Set Eccentric Straps.
Egarons . . . 1 Set Guides with Filling Pieces.
Egarrotte . . . 1 Set Crossheads.
Egauler . . . 1 Set Crosshead Gibs.
Egayantes . . . 1 Set Crosshead Filling Pieces.
Egayasses . . . 1 Set Crosshead Pins.
Egayer . . . 1 Set Rods complete, except Oil Cups.
Egayeras . . . 1 Set Rod Brasses.
Egayions . . . 1 Set Rod Straps.
Egberto . . . 1 Set Rod Keys.
Egdauama . . . 1 Set Rod Straps with Brasses, Keys, Bolts and Set Screws.
Egeenne . . . 1 Set Links complete, with Blocks, Lifters, Eccentric Rods and all Pins.
Egeirino . . . 1 Reverse Shaft.
Egelamus . . . 1 Set Reverse Shaft Bearings.
Egelantier . . . 1 Set Rockshafts.
Egelbeere . . . 1 Set Rocker Boxes.
Egelgras . . . 1 Set Valve Rods.
Egelidamus . . . 1 Counterbalance Spring.
Egelidas . . . 1 Pump Complete.
Egelkruid . . . 1 Pump Plunger.
Egelochus . . . 1 Pump Feed Cock.
Egentium . . . 1 Pump Check complete.
Egenulorum . . . 1 Complete Set of Springs.
Egerane . . . 1 Set Driving Springs.
Egermage . . . 1 Set Driving Spring Links.
Egersimon . . . 1 Set Engine Truck Springs.
Egesaretus . . . 1 Set Tender Springs.
Egesippe . . . 1 Forward Equalizing Beam.
Egestas . . . 1 Forward Equalizing Beam Fulcrum.
Egestione . . . 1 Set Equalizing Beams.
Egestionis . . . 1 Set Equalizing Beam Fulcrums.
Egestorum . . . 1 Bell with Clapper and Tongue.
Egestosi . . . 1 Bell with Clapper and Tongue, Frame, Yoke and Crank.
Egestosus . . . 1 Sand Box complete.
Egestuuum . . . 1 Smoke Stack complete with Base.
Eggaree . . . 1 Smoke Stack Base complete.
Eggebalken . . . 1 Smoke Stack Cone.
Eggehaken . . . 1 Smoke Stack Netting.
Eggemenent . . . 1 Set Grate Bars.
Eggen . . . . 1 Set Grate Frames or Holders.
Eggerigat . . 1 Set Rocking Grates, with all Fixtures.
Eggerling . . 1 Set Engine Truck Boxes with Brasses and Cellars.
Egger . . . . 1 Set Engine Truck Box Brasses.
Eggigheid . . 1 Set Engine Truck Box Cellars.
Eghiazar . . . 1 Set Driving Boxes with Brasses and Cellars.
Egius . . . . 1 Set Driving Box Brasses.
Egidarmato . 1 Set Driving Box Cellars.
Egidio . . . . 1 Set Tender Boxes with Lids, Wedges and Brasses.
Egilifia . . . 1 Set Tender Boxes with Lids.
Egignere . . . 1 Set Tender Box Wedges.
Egigical . . 1 Set Tender Box Brasses.
Eginetique . . 1 Engine Truck complete, with Wheels, Boxes, etc.,
painted and varnished.
Eginopside . . 1 Engine Truck complete, except Wheels and Boxes.
Egiocchus . . 1 Engine Truck Centre Pin.
Egipicina . . 1 Engine Truck Swing Bolster.
Egipcios . . . 1 Engine Truck Frame.
Egipiro . . . . 2 Engine Truck Wheels without Axles, bored.
Egipto logo . . 1 Pair Engine Truck Wheels on Axles, painted and
varnished.
Egirine . . . . 1 Pilot.
Egissent . . . 1 Pilot Bull Nose.
Egiiziache . . 1 Pilot Draw Bar.
Egiziaco . . . 1 Engine Front Draw Casting.
Eglecopala . . 1 Water Gauge complete.
Egloga . . . . 12 Water Gauge Glasses.
Eglogiste . . 1 Water Gauge Lamp.
Egloguista . . 1 Injector.
Eglon . . . . . 1 Injector Steam Valve.
Egmond . . . . 1 Injector Feed Cock.
Egnatia . . . . 1 Injector Check.
Egnatius . . . 1 Steam Gauge.
Egoarico . . . 1 Steam Gauge Stand.
Egoasinha . . 1 Steam Gauge Lamp.
Egobole . . . . 12 Steam Gauge Lamp Globes.
Egober . . . . . 1 Steam Gauge Lamp Stand.
Egofonia . . . 1 Blower Valve.
Egoger . . . . . 1 Heater Valve.
Egoine . . . . . 1 Steam Brake Valve for Engineer.
Egoical . . . . 1 Steam Brake Stop Valve.
Egoismar . . . 1 Blow-off Cock.
Egoismo . . . 1 Set Gauge Cocks.
Egoistical . . . 1 Set Cylinder Cocks.
Egoistique . . . 1 Sight Feed Cylinder Lubricator.
Egoity . . . . 1 Set Cab Cylinder Oilers, B. L. W. style.
Egoletro . . . . 1 Set Condensing Steam Chest Oil Cups.
Egologie . . . . 1 Set Rod Oil Cups.
Egologique . . . 1 Set Guide Oil Cups.
Egomet . . . . 1 Set Rock Shaft Oil Cups.
Egomiste . . . . 1 Set Eccentric Strap Oil Cups.
Egophone . . . . 1 Whistle.
Egopodio . . . . 1 Headlight.
Egopogono . . . 1 Throttle Lever complete, with Quadrant, Latch, Link, Stud, Handle and Spring.
Egoprico . . . . 1 Reverse Lever complete.
Egoprosope . . 1 Reverse Lever Rod, or Reach Rod.
Egorgement . . 1 Set Cab Brackets.
Egorgeoir . . . . 1 Set Cab Bracket Plates.
Egorgeront . . . . 1 Foot Plate.
Egorgille . . . . 1 Tender Wedge.
Egosiller . . . . 1 Tender Wedge Box.
Egotheism . . . . 1 Engine Back Draw Bar.
Egothele . . . . 1 Exhaust Nozzle and Thimbles.
Egotism . . . . 1 Set Exhaust Nozzle Thimbles.
Egotistic . . . . 1 Set Smoke Box Netting.
Egotize . . . . 1 Spark Ejector.
Egotizing . . . . 1 Spark Ejector Valve.
Egout . . . . . 1 Set Smoke Box Cleaning Holes and Caps
Egoutier . . . . 1 Set Driving Brake Shoes.
Egouttage . . . . 1 Set Driving Brake Heads.
Egraffigne . . . . 1 Set Brake Cylinders complete, with Pistons and Rods.
Egrageure . . . . 1 Set Driving Brake Cams.
Egrainage . . . . 1 Tank with Funnel and Lid, Valves, Lugs and Handles, painted and varnished.
Egrainoir . . . . 1 Tank Funnel and Lid.
Egramente . . . . 1 Tank Cock.
Egraminer . . . . 1 Tender, complete on Wheels, painted and varnished.
Egrappage . . . . 1 Tender Chafing Casting.
Egrapper . . . . 1 Tender Front Draw Casting.
Egratigner . . . 1 Tender Back Draw Casting.
Egravoir . . . . 1 Set Tender Frame Centre Pins.
Egregiat . . . . 1 Set Tender Pedestals.
Egregiorum . . . 1 Set Tender Trucks complete, with Wheels painted and varnished.
Egregious . . . 1 Tender truck complete, with Wheels painted and varnished.
Egregores . . . 1 Set Tender Trucks complete, without Wheels and Boxes.
Egrenement . . . 1 Tender Truck complete, without Wheels and Boxes.
Egressao . . . . 1 Set Tender Truck Centre Plates.
Egressed . . . . 1 Set Tender Wheels on Axles, painted and varnished.
Egressing . . . . 1 Pair Tender Wheels on Axle, painted and varnished.
Egribos . . . . . 1 Set Tender Wheels without Axles.
Egrillard . . . . 1 Set Tender Brake Shoes.
Egriot . . . . . . 1 Set Tender Brake Heads.
Egrisage . . . . 1 Cab.
Egritude . . . .
Egrotant . . . .
Egsmeden . . .
Egsmederij . .
Egsmid . . . .
Egtand . . . .
Egtanden . . .
Equaendo . . .
Equalezza . . .
Equalimmo . .
Equalirai . . .
Equalisco . . .
Equalissi . . .
Equalito . . . .
Equelle . . . .
Eguerunt . . .
Eguilles . . . .
Eguimus . . . .
Equisier . . . .
Equsti . . . .
Eqularum . . .
Egurgito . . .
Egyptiaco . . .
Egyptius . . .
Egyptiaque . . .
Egyptien . . .
Egyptology . . .
Ehamote . . .
Ehebett . . .
Ehebruch . . .
Ehebund . . .
Ehefrau . . .
Ehegate . . .
Ehegeld . . .
Ehegemahl . . .
Ehegenosse . . .
Ehegericht . . .
Ehegespons . . .
Ehegestern . . .
Ehehaelfte . . .
Ehejoch . . .
Eheklage . . .
Eheleben . . .
Eheleute . . .
Eheliebe . . .
Ehelos . . .
Ehemals . . .
Ehemann . . .
Eheordnung . . .
Ehepaar . . .
Ehepfand . . .
Eherecht . . .
Ehering . . .
Eheringen . . .
Ehern . . .
Eheschatz . . .
Eheschmied . . .
Eheschuld . . .
Ehesegen . . .
Ehestifter . . .
Ehestunde . . .
Ehevater . . .
Ehevogt
Eheweib
Ehwunsch
Ehodum
Ehontement
Ehoupper
Ehrbarer
Ehrenamt
Ehrenbahn
Ehrenbett
Ehrenbild
Ehrenbogen
Ehrengabe
Ehrengift
Ehrengrab
Ehrengruss
Ehrenhaft
Ehrenkampf
Ehrenkerze
Ehrenkette
Ehrenkranz
Ehrenkreuz
Ehrenkrone
Ehrenlied
Ehrenlohn
Ehrenluege
Ehrenmahl
Ehrenmann
Ehrenmusik
Ehrenpaar
Ehrenplatz
Ehrenpreis
Ehrenpunkt
Ehrenrauch
Ehrenrecht
Ehrenreim
Ehrenrock
TYPES OF LOCOMOTIVES

In order to aid in understanding the class designations more readily, the different types of engines manufactured at these Works, with the class designations of each type, and the kind of service for which they are specially designed or adapted, are shown by line illustrations, in the following pages.

Reference is made also to the explanation of the system of classification adopted, which is to be found on pages 107 to 109.
5 A (RACK RAIL TYPE).
MOUNTAIN SERVICE.

6 B.
INSPECTION SERVICE.
6 D WITH TENDER.
HEAVY SWITCHING SERVICE.

8 D MOGUL.
FREIGHT SERVICE.
12\(\frac{1}{4}\) E TANK.
CAN ALSO BE USED WITH TENDER.
ILLUSTRATED PLATES.
Plate 1.
BOILER AND ATTACHMENTS.

Plates 1 and 2. EHRENRUF.

Ehrensaal . . . 1. Boiler.
Ehrensitz . . . 2. Fire Box.
Ehrensoak . . . 2a. Front Tube Sheet.
Ehrensob . . . 2b. Firebox “ “
Ehrensoen . . . 2c. Water Space Frame.
Ehrensold . . . 3. Dome.
Ehrenstamm . 3. “ Ring.
Ehrenstufe . . . 5. “ Cap.
Ehrentag . . . 6. “ Base.
Ehrentanz . . . 7. “ Casing.
Ehrenthat . . . 8. “ Cover.
Ehrentheil . . 9. Throttle Valve.
Ehrenthron . 10. “ “ Box.
Ehrentitel . . 11. “ Pipe.
Ehrenwein . . 15. “ “ Stem.
Ehrenwort . . 16. “ Stuffing Box.
Ehretia . . . 18. Dry Pipe.
Ehrgeiz . . . . 20. “ Ring on Tube Sheet.
Ehrgeizig . . 21. Tubes.
Ehrlich . . . 22. Double Cone.
Ehrliebig . . 23. Steam Pipes, R and L.
Ehrsucht . . . 24. Smoke Box Ring Front.
Ehrtrieb . . . 24A. “ “ “ Middle.
<table>
<thead>
<tr>
<th>Name</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eibisch</td>
<td>25</td>
<td>Smoke Box Front.</td>
</tr>
<tr>
<td>Eiceti</td>
<td>26</td>
<td>&quot;    &quot; Door.</td>
</tr>
<tr>
<td>Eichapfel</td>
<td>27</td>
<td>&quot;    &quot; Liner.</td>
</tr>
<tr>
<td>Eichelganz</td>
<td>28</td>
<td>Number Plate.</td>
</tr>
<tr>
<td>Eichelmast</td>
<td>29</td>
<td>Smoke Stack Base.</td>
</tr>
<tr>
<td>Eichelmaus</td>
<td>30</td>
<td>Fire Door.</td>
</tr>
<tr>
<td>Eichelnapf</td>
<td>31</td>
<td>&quot;    &quot; Frame.</td>
</tr>
<tr>
<td>Eichen</td>
<td>32</td>
<td>&quot;    &quot; Liner.</td>
</tr>
<tr>
<td>Eichenast</td>
<td>33</td>
<td>Corner Plug.</td>
</tr>
<tr>
<td>Eichenhain</td>
<td>34</td>
<td>Fusible &quot;</td>
</tr>
<tr>
<td>Eichenlaub</td>
<td>35</td>
<td>Waist &quot;</td>
</tr>
<tr>
<td>Eichenlohe</td>
<td>36</td>
<td>Lagging.</td>
</tr>
<tr>
<td>Eichenmoos</td>
<td>37</td>
<td>Jacket.</td>
</tr>
<tr>
<td>Eichenreis</td>
<td>38</td>
<td>Smoke Box Band.</td>
</tr>
<tr>
<td>Eichenrose</td>
<td>39</td>
<td>Safety Valve.</td>
</tr>
<tr>
<td>Eichenwald</td>
<td>40</td>
<td>&quot;    &quot; Stem.</td>
</tr>
<tr>
<td>Eichhase</td>
<td>41</td>
<td>&quot;    &quot; Spring.</td>
</tr>
<tr>
<td>Eichhase</td>
<td>42</td>
<td>&quot;    &quot; Cap.</td>
</tr>
<tr>
<td>Eichhorn</td>
<td>43</td>
<td>Relief Lever.</td>
</tr>
<tr>
<td>Eichkatze</td>
<td>44</td>
<td>Crown Bar.</td>
</tr>
<tr>
<td>Eichkranz</td>
<td>45</td>
<td>Staybolt.</td>
</tr>
<tr>
<td>Eichnuss</td>
<td>46</td>
<td>Spark Ejector.</td>
</tr>
</tbody>
</table>

In ordering steam pipes (No 23), it will be necessary to specify the side, if both are not wanted.

Smoke stack base (No. 29), while shown in one piece on this plate, is frequently made in two parts, as shown on Plate 31, and either part can be had by referring to the latter plate. See Plate 4 for steel base.

Jacket bands are not given a number in this list, as they are easily designated without.

In many cases patented valves are used instead of the safety valve shown on this plate. In ordering, state whether valve is wanted with or without relief lever.
ARRANGEMENT OF FIRE BRICKS IN FIRE BOX.

Plate 3. EICHOCHS.

Fig. I.—Bricks supported on Tubes.

Eichstab . . . 1. Fire Brick.
Eichtraube . . 2. " " Tube.
Eicimus . . . 3. " " Plug, Front.
Eidechse . . . 4. " " " Back.

Fig. II.—Bricks supported on Studs.

Eiderbett . . 5. Fire Brick Stud.
PRESSED STEEL SMOKE BOX FRONT, CYLINDER HEAD COVER AND STACK BASE.

Plate 4. EIDERDAUNE.

Eiderdons . . . 1. Smoke Box Front.
Eidereend . . 2. " " Door.
Eidergans . . . 3. Cylinder Head Cover, Front.
Eidervogel . . 4. " " " Back.
Eidesmann . . 5. Stack Base.

Plates 1 and 2 show cast iron smoke box fronts and stack bases, and Plate 5 cast iron cylinder head covers. These have in recent years been superseded on many railroads by similar parts made of steel sheets pressed while hot in dies giving them the required forms. They are much stronger, and consequently more durable than cast iron, present a simple, neat appearance, and in many cases when injured can be brought back to their original shape.
SINGLE EXPANSION CYLINDER, STEAM CHEST AND ATTACHMENTS.

Plate 5. EIDFEST.

Eidgesell . 2. Front Head.  
Eidiertje . 3. Back "  
Eidotograph . 4. Front Casing Cover.  
Eidon . 5. Back "  
Eidopsare . 6. Cylinder Gland, R. & L.  
Eidothee . 7. " " Bottom Ring.  
Eidotrope . 8. Wood Lagging.  
Eieraapfel . 9. Casing.  
Eierbier . 10. Steam Chest.  
Eierblume . 11. " " Cap.  
Eierdooir . 13. " " " Bottom Ring.  
Eierdopje . 15. " " Casing.  
Eiergerste . 16. " " Valve.  
Eierghant . 16A. " " " Balanced Pattern.  
Eiergome . 16B. " " " Packing Strips.  
Eierhorst . 16C. " " " " Springs.  
Eierkanaal . 17. " " " Yoke.  
Eierkel . 18. " " Joint.  
Eierkoek . 19. " " Oil Pipe Stem.

If a single cylinder, head, gland, or steam chest is ordered, the side required for should be specified.
Plate 6.
Baldwin Compound Cylinders (Four Cylinder—Vauclain System).

Plate 6. EIERKOEKJE.

Baldwin Compound Cylinders with Low Pressure Cylinder above High Pressure, showing one side of locomotive.
The High and Low Pressure Cylinders are cast in one piece.
Baldwin Compound Cylinders (Four Cylinder—Vauclain System).

Plate 7. Eierkooper.

Baldwin Compound Cylinders with High Pressure Cylinder above Low Pressure, showing one side of locomotive.

The High and Low Pressure Cylinders are cast in one piece.
Plate 8.

Diagram showing course of steam in four cylinder compound locomotive.
DIAGRAM OF BALDWIN COMPOUND CYLINDERS (VAUCLAIN SYSTEM) SHOWING THE COURSE OF STEAM IN THE CYLINDERS AND VALVE CHAMBER.

Plate 8. EIERKRAMER.

Eierlage . 2. High Pressure Front Cylinder Head.
Eierlijst . 3. " " Back " "
Eiermand. 4. " " Front " " Casing Cover.
Eiermarkt. 5. " " Back " " "
Eiermelk. 6. Low " Front " "
Eiernilch . 7. " " Back " "
Eiermuus. 8. " " Front " " Casing Cover.
Eiernapf . 9. " " Back " " "
Eiernetjes . 10. Front Valve Chamber Head.
Eiernudel . 11. Back " " "
Eierpruim . 12. Front " " " Casing Cover.
Eiersack . 13. Back " " " "
Eiersalat . 14. Valve Chamber Bushing. (See Plate 9.)
Eiersaus . 15. Piston Valve. " "
Eierschaal . 16. " " Stem. " "
Eierschaum 17.*High Pressure Cylinder Gland.
Eierschuit . 18.*Low " " "
Eierslak . 19.*Valve Chamber Gland.

If a single cylinder, head, casing cover, bushing, valve, stem, or gland is ordered, the side required for should be specified.

* Metallic Packing is used in all Stuffing Boxes of Compound Cylinders. (See Plate 79.)
PISTON VALVE AND BUSHING FOR BALDWIN COMPOUND LOCOMOTIVE (VAUCLAIN SYSTEM).

Plate 9. EIERSOEP.

Eierspeise . . . 1. Piston Valve.
Eierstab . . . 2. " " Packing Ring.
Eierstein . . . 3. " " Stem.
Eierstock . . . 4. Valve Chamber Bushing.

If a single valve, stem, or bushing is ordered, the side required for should be specified.
ARRANGEMENT
When High Pressure Cyl. is ABOVE

ARRANGEMENT
When High Pressure Cyl. is BELOW
ARRANGEMENT OF STARTING VALVES AND CYLINDER COCKS FOR BALDWIN COMPOUND LOCOMOTIVE (VAUCLAN SYSTEM).

Plate 10. EIERSTERRUF.

1. Eiersuppe . Starting Valve Lever in Cab.
2. Eiertaart . " " " Fulcrum in Cab.
3. Eiertanz . " " Rod from Cab.
5. Eiertiegel . Lower "
7. Eiervla . Starting Valve Rod under Cylinder.
8. Eiervrouw . Cylinder Cock " " "
CYLINDER COCK WORK, FOR SINGLE EXPANSION LOCOMOTIVES.

Plate II. EIFERHEISS.

Eiferliebe ... 1. Upper Arm.
Eifermuth ... 2. Lower "
Eiferopfer ... 4. " Bearing.
Eifersucht ... 5. Cock Strips.
Plate 12.
VACUUM VALVE FOR LOW PRESSURE CYLINDER PORTS (VAUCLAIN SYSTEM).

Plate 12. EIFRIGSTEN.

Eigenares . . . 1. Low Pressure Port Vacuum Valve.
Plate 13.
RELIEF VALVE FOR LOW PRESSURE CYLINDER HEADS (VAUCLAIN SYSTEM).

Plate 13. EIGENART.

*Eigenartig* 1. Low Pressure Cylinder Head Relief Valve, Front.

*Eigenbaat* 2. " " " " " " " Back.

In ordering a single valve, state whether it is wanted for front or back cylinder head.
COMBINED RELIEF AND VACUUM VALVE FOR
LOW PRESSURE CYLINDER HEADS (VAU-
CLAIN SYSTEM).

Plate 14. EIGENBATIG.

**Eigendom** . . . 1. Low Pressure Cylinder Head Relief and Vacuum Valve, Front.

**Eigendunk** . . . 2. Low Pressure Cylinder Head Relief and Vacuum Valve, Back.

In ordering a single valve, state whether it is wanted for front or back cylinder head.
FRAMES AND PEDESTALS.

Plate 15. EIGENEN.

Eigengrund . . 1. Top Rail and Pedestals.
Eigengut . . 2. Front Rail.
Eigenheit . . 3. " " Top.
Eigenhilfe . . 4. " " Bottom.
Eigening . . 5. Middle Brace.
Eigenleben . . 6. Back "
Eigenlijk . . 7. Frame Filling Piece.
Eigenlob . . 8. Pedestal Wedge.
Eigenmacht . . 9. " " Bolt.
Eigenname . . 10. " Gib.

While this plate does not show the pedestal bolted to the frame rail, engines have been constructed on this plan, and when ordering a pedestal to replace, it will only be necessary to refer to its position on the frame.
Plate 16.
DRIVING WHEELS, AXLE AND TIRES.

Plate 16. EIGENNATUR.

Eigennutz . . 1. Axle.
Eigenrache . . 2. Eccentric.
Eigenruhm . . 3. Wheel Centre (Cast Iron).
Eigenrupe . . 4. " " (Cast Steel).
Eigenschap . . 5. Wrist Pin.
Eigensinn . . 6. Tire.

Orders for wheels or their parts, when not in full set, should indicate particular pair of wheels required, or that parts are needed for.
Plate 17.
WRought IRoN DRIVING WHEEL CENTRE
(VAUCLAiN TYPE).

Plate 17. EIGENTLICH.

Eigenwaan . . . Driving Wheel Centre.

For many years cast iron has been used in the United States for driving wheel centres. Lately, however, on account of the increased severity of locomotive service, a demand has arisen for stronger wheels, and this has been met by the wrought iron centre here described.

The method of manufacture is plainly shown by the drawing. The parts are forged separately under drop and steam hammers and a hydraulic machine, and assembled as shown by the dotted lines. They are then brought to a welding heat and placed between steel dies of suitable dimensions, the upper one being connected to the piston rod of a powerful steam hammer. A few blows then weld the parts together, making a homogeneous, solid forging.

These wheels possess great strength, lightness, and beauty of design. The counterbalance is filled with lead when necessary to bring it to the required weight.

For clearer illustration of method of manufacture, see Plate 18, Fig. 1.
WROUGHT IRON ENGINE TRUCK AND TENDER WHEEL (VAUCLAN TYPE).

Plate 18. EIGENWELT.

Eigenwerth . . . 1. Wheel Centre.
Eigenwijs . . . . 2. Retaining Ring.
Eigenwille . . . 3. Tire.

The conditions which brought forth the wrought iron driving wheel have caused the existence of the engine truck and tender wheel of the same type. The construction is shown by Fig. 1. The tire is shrunk on the centre and is further secured by two wrought iron retaining rings held by rivets (see Fig. 2). The steel tire lasts much longer than the chilled tread of a cast iron wheel, and when, after having been turned several times, it is finally worn too thin for use, it can be replaced by a new one; whereas, when the tread of a cast iron wheel is worn through the chill, the whole wheel must be thrown away.

For the position of these wheels in the locomotive, see Plates 34 and 64.
GUIDE BEARER, GUIDES AND CROSSHEAD FOR SINGLE EXPANSION LOCOMOTIVES.

Plate 19. EIGHTEENMO.

Eightfold . . . 2. " " Knee.
Eighthly . . . 3. Top Guide Bar.
Eigilbert . . . 5. Guide Fillings.
Eigilwich . . . 6. Crosshead.
Eihaut . . . . 7. " Gibbs.
Eikeboom . . . 9. " Plate
Eikeboomen . . 10. " Pin.
Eikekrans . . . 11. " Key.

Orders for guides, when not in full sets, should specify whether top or bottom guides are wanted, and for crosshead the side should be given.
GUIDE BEARER, GUIDES AND CROSSHEAD FOR
SINGLE EXPANSION LOCOMOTIVES.

Plate 20. EIGHTEENMO.

Eightfold . . . 2. " " Knee.
Eighthly . . . 3. Top Guide Bar.
Eigilbert . . . 5. Guide Fillings.
Eigilwich . . . 6. Crosshead.
Eihaut . . . . . 7. " Gibbs.
Eikeboom . . . . 9. " Plate.
Eikeboomen . . 10. " Pin.
Eikekrans . . . 11. " Key.

Orders for guides, when not in full sets, should specify whether top or bottom guides are wanted, and for crosshead the side should be given.
GUIDE BEARER, GUIDES AND CROSSHEAD FOR BALDWIN COMPOUND LOCOMOTIVES (VAU-CLAIN SYSTEM).

Plate 21. EIKEKROON.

Eikelaars ... 1. Guide Bearer.
Eikeldop ... 2. " " Knee.
Eikelmuis ... 3. Top Guide Bar.
Eikeloof ... 4. Bottom Guide Bar.
Eikeloogst ... 5. Guide Front Filling or Block.
Eikels ... 5A. " Back " " "
Eikelsteen ... 6. Crosshead.
Eikeltijd ... 10. " " Pin.

Orders for guides, when not in full sets, should specify whether top or bottom guides are wanted, and for crosshead the side should be given.
VALVE STEM GUIDES AND CROSSHEAD FOR BALDWIN COMPOUND LOCOMOTIVES (VAU-CLAIN SYSTEM).

Plate 22. EIKELTJES.

Eikenbast . 2. " " Bottom Guide Bar.
Eikenbosch . 3. " " Guide Front Filling or Block.
Eikenhout . 4. " " " Back " " "
Eikenlaan . 5. " " Crosshead Lug.
Eikenmos . 6. " " Crosshead.
Eikenplant . 7. " " " Pin.

Orders for valve stem guides, when not in full sets, should specify whether top or bottom guides are wanted; and for crosshead the side should be given.
VALVE MOTION WORK.

Plate 23. EIKENVAREN.

Eikenwoud  1. Axle.
Eikon .... 2. Eccentrics.
 4. " " Back "
Eiland .... 5. " Rod, Inside (Forward Motion).
Eilandjes . 6. " " Outside (Back " ).
Eilbote .... 7. Reverse Link, Back Half.
Eileithyia . 8. " " Front "
Eilfertig ... 9. " " Filling Piece.
Eiloof ..... 11. Sliding Block.
Eilpost .... 12. Link Lifter.
Eilritt .... 13. Reverse Shaft.
Eilzug .... 15. Reverse Shaft Bearing.
Eimer .... 16. " Lever Rod.
Eimerbank . 17. Rock Shaft.
Eimerkette . 18. " " Box.
Eimermasse . 19. Valve Rod.

Orders for reverse shaft bearings, rock shaft boxes, and link work, when not in sets, should specify the side required for.
ROCKSHAFT ROD AND HANGER FOR BALDWIN COMPOUND LOCOMOTIVES (VAUCLAIN SYSTEM).

Plate 24. **EIMERWEISE.**

- - - - - - - -

Einachsige . . 1. Rockshaft Rod.
Einackern . . . 2. " " Hanger.
Einaetzen . . . 3. " " Bearing.
Einaeugig . . . 4. " " Oil Cup.

Orders for rockshaft rods, hangers and bearings, when not in sets, should specify the side required for.
RODS, STRAPS AND BRASSES.

Plates 25 and 26. EINANDER.

Einarmig ... A. Main Rod.
Einathmen ... B. Back Parallel or Side Rod.
Einballen ... C. Second " " " "
Einband ... D. Third " " " "
Einbandeln ... E. Fourth " " " "

Einbein ... 8. Strap of Stub 1.
Einbeinig ... 9. " " " 2.
Einbetteln ... 10. " " " 3.
Einbildsam ... 11. " " " 4.
Einbildung ... 12. " " " 5.
Einbinden ... 13. " " " 6.
Einbisamen ... 14. " " " 7.
Einblatt ... 15. Brass " " 1.
Einblick ... 16. " " " 2.
Einddoel ... 17. " " " 3.
Eindelijk ... 18. " " " 4.
Eindeloos ... 19. " " " 5.
Eindklank . . 22. Key " " 1.
Eindletter . . 23. " " " 2.
Eindorren . . 24. " " " 3.
Eindpaal . . 25. " " " 4.
Eindruck . . 27. " " " 6.
Eindteeken . . 28. " " " 7.
Eindvonnis . . 29. Bolt.
Einerhand . . 30. Set Screw.
Einfaedeln . . 31. Jaw Pin for Rod B.
Einfesseln . . 32. " " " C.
Einfilzen . . 33. " " " D.
Einflecken . . 34. " " " E.

When rods are not ordered in full sets, the side for which the parts are wanted should be given, as well as the letter of the rod and the stub number.

Give the stub number in all cases when ordering straps, brasses, keys, bolts, or set screws.
Plate 27.
PISTONS AND PACKING RINGS.

Plate 27. EINFLUG.

Einfluss ... 1. Piston Head.
Einfoermig  2. " Follower.
Einfordern  3. " " Bolts.
Einfrage ... 5. " Rod.
Einfrieden  6. " " Key.
Einfuhr ... 7. " " Nut.
Eingabe ... 9. " T Ring (Cast Iron).

This plate indicates four kinds of packing generally used, and customers can readily refer to the particular pieces by the number of the piece, as well as the figure number.
SPRINGS AND EQUALIZING WORK.

Plates 28, 29 and 30. EINGEHOLT.

Eingeimpft . . 1. Forward Driving Spring.
Eingejagt . . 2. Second " "
Eingekauft . . 3. Third " "
Eingekehrt . . 4. Fourth " "
Eingekerbt . . 5. Fifth " "
Eingekramt . . 6. Forward Truck Equalizing Beam.
Eingelangt . . 7. Driving Equalizing Beam, First.
Eingelegt . . 8. " " " Second.
Eingelenkt . . 9. " " " Third.
Eingelocht . . 10. " " " Fourth.
Eingeloest . . 11. Forward " " Link.
Eingelullt . . 12. " " " Fulcrum.
Eingemacht . . 12A. Driving " " "
Eingepackt . . 15. Forward Truck Centre Pin Bolt.
Eingepiched . . 16. Transverse Equalizing Beam.

In ordering from these plates, it is necessary to specify the figure as well as the number of piece, as it will be noticed that the same numbers have different shapes on the different figures.
SMOKE STACKS.

Plate 31. EINGERAFFT.

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eingerahmt</td>
<td>1. Base</td>
</tr>
<tr>
<td>Eingesalbt</td>
<td>2. &quot; Flange.</td>
</tr>
<tr>
<td>Eingesandt</td>
<td>3. Cone.</td>
</tr>
<tr>
<td>Eingesehen</td>
<td>4. Top.</td>
</tr>
<tr>
<td>Eingesetzt</td>
<td>5. Netting.</td>
</tr>
<tr>
<td>Eingreifen</td>
<td>7. Chamber.</td>
</tr>
<tr>
<td>Einguss</td>
<td>8. Inside Pipe.</td>
</tr>
<tr>
<td>Einhaekeln</td>
<td>9. Hand Hole and Plate.</td>
</tr>
</tbody>
</table>

In ordering top parts of "Diamond" plan of stack, the order should always specify whether top or bottom part of No. 4 is wanted when both pieces are not required.
PILOT AND FRONT BUMPER, IRON DRAW BAR ATTACHMENT.

Plate 32. EINHAEUSIG.

| Einhageln   | 1. Bumper.  |
| Einhard     | 2. Stiffening Plate. |
| Einharken   | 3. Pilot Frame. |
| Einheizen   | 5. " Bottom Band. |
| Einhergang  | 7. " " Shoe. |
| Einhuellen  | 8. Bottom Plate. |
| Einjagen    | 11. Middle Brace. |
| Einjaket    | 12. Smoke Box Brace. |
| Einjut      | 15. " " Spring. |

The bracket No. 10 is made right and left, and when only one is wanted the side required for should be specified.
PILOT AND FRONT BUMPER, BULL NOSE ATTACHMENT.

Plate 33. EINKELTERN.

Einkrachen . 1. Bumper.
Einladung . . 2. Stiffening Plate.
Einlangen . . 3. Pilot Frame.
Einlappen . . 4. " Bars.
Einlassen . . 5. " Bottom Band.
Einlaut . . . . 6. " Draw Casting.
Einlautig . . 7. " " " Support.
Einlenkung . 8. Bottom Plate.
Einliefern . . 9. Pushing Shoe.
Einlochen . . 10. Pilot Bracket.
Einloesung . 11. Middle Brace.
Einlomen . . 12. Smoke Box Brace.
ENGINE TRUCKS.

Plate 34. EINMAHLEN.

Einmahn . . . Fig. 1.—Two Wheeled or Pony Truck.
Einmahnly . . . Fig. 2.—Four " Truck.
   Einmaster . . 1. Centre Pin.
   Einmeilig . . 2. Swing Bolster.
   Einmelken . . 3. " " Crosstie.
   Einmischen . 4. " " Link.
   Einmuethig . . 5. Truck Frame.
   Einnarben . . 7. " " Cap.
   Einnesteln . . 8. Equalizing Beam.
   Einnisten . . 9. Spring Link.
   Einoede . . . . 10. Axle.
   Einoelen . . . 11. Wheel.
   Einomenie . . 12. Radius Bar.
   Einpacken . . 14. Longitudinal "
   Einpichen . . 15. Spring Staple.
   Einpraegen . . 17. Safety Strap.

This plate embodies both the pony and ordinary four-wheel truck, and in ordering parts by the designating numbers the figure number should first be given.
ENGINE TRUCK CENTRE PIN GUIDE AND CROSSTIE, RADIUS BAR CROSSTIE AND CLAMP.

Plate 35. EINRAFFEN.

Einrahmen . . . 1. Engine Truck Centre Pin Guide.
Einrammeln . . . 2. " " " " "
Einraunen . . . 3. " " " " Crosstie.
Einreiten . . . 4. " " Radius Bar Crosstie.
Einrippig . . . 5. " " " " "
Einrollbar . . . 6. " " " " Clamp.
Einrosten . . . 7. " " " " Pin.
SAND BOX AND BELL WORK.

Plate 36. EINRUDERN.

Einsalzende... Fig. 1.—Sand Box.

Einsam... 1. Base.
Einsamig... 2. Top.
Einsargen... 3. Lid.
Einsatz... 4. Body.
Einschlag... 5. Valve.
Einschlupf... 6. Lever.
Einseifen... 7. Valve Connecting Rod.
Einsetzen... 8. Pipe Flange.

Einspannen... Fig. 2.—Bell and Frame.

Einspruch... 1. Bell.
Einsteigen... 2. Frame.
Einstig... 3. Yoke.
Einstmals... 4. Crank.
Einstopfen... 5. Tongue.
Einstreu... 6. Acorn.
FOOT BOARDS AND WHEEL COVERS.

Plate 37. EINSTREUEN.

Einstutzen . . 1. Cab Foot Board.
Eintaegig . . 2. Running "
Eintausch . . 3. Cab Foot " Brackets.
Eintoenig . . 4. Running " "
Eintracht . . 5. Wheel Cover.
Einungstag . . 6. " " Pipe.
Einwaerts . . 7. " " Acorn.
Einzaehlig . . 8. " " Bracket.
Einzahl . . 9. " " Column.

These parts are seldom ordered except in full sets, and the side wanted for should be given when they are not so ordered.
BACK BUMPER AND ATTACHMENTS.

Plate 38. EINZAHLUNG.

Einzelbach . . . 1. Cab Bracket.
Einzelbild . . . 2. " " Plate.
Einzeln . . . . 3. " " Pipe.
Einzelwort . . . 4. Back Bumper.
Einzelp . . . 5. Engine Step.
Einzieher . . . 6. " " Hanger.
Einzig . . . . 7. Foot Plate.
Einzwingen . . 8. Tender Wedge.
Eionale . . . 9. " " Box.

Cab brackets are made right and left. Orders for single brackets should give side wanted for.
Plate 39.
ROCKING GRATE WORK.

Plate 39. EIRENARCH.

Eirund . . . . 1. Bar.
Eisachat . . . 2. Frame.
Eisbaelle . . . 3. Connecting Bar.
Eisbaertig . . 4. Arm.
Eisbahn . . . . 5. Rod.
Eisbank . . . . 6. Handle.
Eisbecher . . . 7. Shaft.
Eisberg . . . . 8. " Bearings.
Eisbergen . . . 9. Drop Plate.
Eisblock . . . 10. " " Handle.
Eisblume . . . 11. " " Shaft.
Eisch . . . . . 12. " " " Bearing.

When complete sets of these bars are not wanted, the order should give
the position from the front, of the bars that are required.
ROCKING GRATE WORK.

Plate 40. EISCHENDE.

Eiseiche . . . 1. Bar.
Eisenader . . 2. Frame.
Eisenalaun . . 3. Connecting Bar.
Eisenbarre . . 4. Lever.
Eisenerz . . . 5. " Rod.
Eisenfest . . . 6. " Handle.
Eisenfleck . . . 7. Drop Plate.
Eisengang . . 8. " " Rod.
Eisengeld . . . 9. " " Crank.
Eisenglanz . . 10. " " " Handle.
Eisengrube . . 11. " " " Bearing.

When complete sets of these bars are not wanted, the order should give the position from the front, of the bars that are required.
PLAIN GRATE FOR WOOD.

Plate 41. EISENHAKEN.

- - - -

Eisenholz . . 1. Bar.
Eisenhose . . 2. Dead Plate.
Eisenjoch . . 3. End Holder.

For this plan of grate it will be necessary to specify the side dead plate is required for when not in full sets.
PLAIN GRATE FOR SOFT COAL.

Plate 42. EISENKALK.

Eisenkeil . . . 1. Bar.
Eisenklaue . . 2. Dead Plate.
Eisenmauer . . 3. End Holder.
Eisenmohr . . 4. Drop Plate.
Eisenmulm . . 5. " " Handle.
Eisennuss . . 6. " " " Support.
Eisenocher . . 7. " " Shaft.
Eisenofen . . 8. " " " Bearing.

The bearings for drop plate shaft are made right and left. This should be observed in ordering duplicates.
SMOKE BOX FITTINGS.

Plate 43. EISENOPAL.

Eisenprobe ... 1. Exhaust Nozzle.
Eisenrahm ... 2. Netting.
Eisenring ... 3. Deflecting Plate.
Eisenrost ... 4. " " Slide.
Eisensalz ... 5. Spark Ejector.
Eisensand ... 6. Cleaning Hole and Cap.
Eisenschuh ... 7. Exhaust Thimbles.

In ordering these parts, if any change is required from original fittings, especially with reference to nozzle, the order should specify whether single or double opening is wanted. Thimbles always include three sizes to a set, and the particular size wanted, when not in full sets, should be given.
THROTTLE AND WHISTLE WORK.

Plate 44. EISENСПITZ.

Eisensporn . . . . Fig. 1.—Throttle Work.

Eisenstark . . . . 1. Lever.
Eisenstaub . . . . 2. Quadrant.
Eisenstich . . . . 3. Latch.
Eisenstufe . . . . 4. " Link.
Eisenthor . . . . 5. Rod.
Eisenthurm . . . . 6. Jaw.
Eisentritt . . . . 7. Link.
Eisenwaare . . . . 9. Handle.
Eisenwaffe . . . . 10. " Spring.

Eisenzahn . . . . Fig. 2.—Whistle Work.

Eisenzeit . . . . 1. Lever.
Eisenzeug . . . . 2. Arm or Crank.
Eisenzoll . . . . 3. Shaft.
Eiseshauch . . . . 4. " Bearing.
Eisflöh . . . . . . 5. Link.

In ordering Link No. 5, Fig. 2, the distance from centre to centre of jaw should be given.
REVERSE LEVER AND ATTACHMENTS.

Plate 45.  EISFUCHS.

Eisgang . . . . . 1. Lever.
Eisgipfel . . . . 2. Fulcrum.
Eisgrau . . . . . 3. Handle.
Eishoehle . . . . 4. Latch.
Eishund . . . . . 5. " Spring.
Eisinsel . . . . . 6. " Rod.
Eiskaeltc . . . . 7. Catch.
STEAM BRAKE WORK.

SPREAD STYLE.

Plate 46. EISKEGEL.

Eiskeller . . . . 1. Brake Cylinder.
Eiskessel . . . . 2. " Piston Rod.
Eiskluft . . . . 3. " Cylinder Head, Bottom.
Eisklumpen . . 3A. " " Top.
Eislæufer . . . . 4. " " Stuffing Box Nut.
Eislawine . . . . 5. " Connecting Link.
Eisloch . . . . 6. " Hanger Link.
Eismeer . . . . 7. " Head.
Eismanat . . . . 9. " Bell Crank.
Eismuetze . . . . 10. " Rod.
Eisnadel . . . . 11. " " Adjusting Nut.
Eispalast . . . . 13. " Hanger "

Separate catalogues of patented power brakes may be obtained by applying to the makers.
STEAM BRAKE WORK.
EQUALIZED STYLE.

Plate 47. EISPNOIQUE.

Eispol . . . . 1. Brake Cylinder.
Eispunkt . . . 2. " Piston Rod.
Eisrechen . . 3. " Cylinder Head.
Eisrevier . . . 4. " " Stuffing Box Nut.
Eisriegel . . . 5. " Connecting Link.
Eisrinde . . . 6. " Lever.
Eissamp . . . 7. " Head.
Eissaugue . . 8. " Beam.
Eisschuh . . . 9. " Shaft.
Eisspitzen . . 10. " Rod.
Eissporn . . . 11. " " Adjusting Nut.
Eistafel . . . 15. " " Bearing.
Eistanz . . . 16. " Rod Lever.

Separate catalogues of patented power brakes may be obtained by applying to the makers.
JOURNAL BOXES.

Plate 48. EISTHAU.

Eistorm . . .  Fig. 1.—Driving Box.
Eistormly . .  Fig. 2.—Truck "

Eistropfen . .  1. Box.
Eisufer . . .  2. Cellar.
Eisvogel . . .  3. Brass.
Eiswand . . .  4. Cellar Bolt.

Eiswasser . . .  Fig. 3.—Tender Box.

Eiswelt . . .  1. Box.
Eiswolke . . .  2. Wedge.
Eiswurm . . .  3. Brass.
Eiszacken . . .  4. Lid.
Eiszapfen . . .  5. Axle.
PUMP WORK.

Plate 49. EISZONE.

Eitelhans . . . . 1. Pump Barrel.
Eitelkeit . . . . 2. TcP Chamber.
Eitelsucht . . . . 3. Bottom Chamber.
Eiterbeule . . . . 4. Valve.
Eiterblase . . . . 5. " Cage.
Eiterig . . . . . . 6. Plunger.
Eiterperle . . . . 7. Gland.
Eitjes . . . . . . 8. " Bottom Ring.
Eiulazione . . . . 9. " Studs.
Eivol . . . . . . 10. Chamber Studs.
Eivormig . . . . 11. Check Pipe.
Eiwit . . . . . . 13. Feed Pipe.
Eiwitten . . . . 15. Pet Cock.
Eixerdar . . . . 16. " " Lever in Cab.
Ejacularacao. . . 17. " " " Fulcrum.
Ejaculador . . . . 18. " " " Rod.
Ejaculamur . . . . 19. " " " " Guide.
Ejacular . . . . 20. " " Crank.
Ejacularis . . . . 21. " " " Hanger.
Ejaculavi . . . . 22. " " " Rod.
Ejaculo . . . . . . 23. " " " Jaw.
Ejambe . . . . . . 24. " " Lever "

In ordering pump barrel, the side wanted for should be indicated in the order.
PUMP CHECK AND FEED COCK.

Plate 50. EJARRAGE.

Ejarre . . . . Fig. 1.—Pump Check.

Ejeccao . . . 1. Check Body.
Ejecimus . . 2. " Flange.
Ejecissem . . 3. " " Studs.
Ejecteur . . . 4. Valve.
Ejecticio . . 5. " Seat.
Ejectments . 7. Casing.
Ejectura . . . 8. Check Pipe Coupling Nut.

Ejecturis . . . Fig. 2.—Feed Cock.

Ejectuum . . 9. Feed Cock Body.
Ejecucion . . 10. " " Plug and Nut.
Ejecutada . . 11. Hose Coupling Nut.
Ejecutar . . . 13. Feed Pipe.
FEED WATER WORK.

Plate 51. EJECUTARON.

Ejecutases ... 1. Shaft.
Ejecutiva ... 2. " Quadrant.
Ejecutivos ... 3. " Handle.
Ejecutoria ... 4. " Hanger.
Ejemplares ... 5. " Rod.
Ejeratio ... 6. Cock Shaft.
Ejerceis ... 7. " Bearing.
Ejercer ... 8. " Hanger.
Ejerceras ... 9. Cock.
Ejercicios ... 10. Pipe Clamp.
HEADLIGHT SHELVES AND SIGNAL LIGHT BRACKET.

Plate 52. EJERCIDOS.

Ejercieron . . . . 1. Headlight Shelf Column.
Ejerciteis . . . . 2. " " Edge.
Ejerzo . . . . . . 3. " Shelf.
Ejidos . . . . . . 4. " Bracket.
Ejointage . . . . 5. Signal Light Bracket.

Headlight brackets are made right and left, and orders for single brackets should specify the side.
WHISTLE, STEAM GAUGE STAND AND DRIP FUNNEL.

Plate 53. EJOUIR.

Ejulabilis . . . 1. Whistle Bell.
Ejulabis . . . 2. " Bowl.
Ejulabo . . . 3. " Valve.
Ejulandi . . . 4. " Lever.
Ejulandos . . . 5. Steam Gauge Stand.
Ejulandum . . 6. Cab Lamp "
Ejulas . . . . 7. Gauge Cock Drip Funnel.
INJECTOR VALVES.

Plate 54. EJULATION.

Ejulatos ...... 1. Steam Valve.
Ejulatum ...... 2. Feed "
Ejulavi ...... 3. Check "

In ordering these parts, if they are required for any change from original dimensions, or additional to what was first put on the engine, the size and kind of pipes to be used should be specified.
VALVES AND COCKS.

Plate 55. EJULAVISTI.

Ejulitabo . . . . 1. Blower, Heater, Steam Brake Stop Valve or Spark Ejector Valve.
Ejulitamus . . . . 2. Drip Cock.
Ejulitas . . . . 3. Blow-off Cock.
Ejulito . . . . 4. Cylinder Cock (Buchanan style).
Ejulo . . . . 5. " Cock.
Ejuncesco . . . . 6. Gauge "
Ejuncido . . . . 7. Steam Chest Relief Valve.

In ordering cylinder cocks when not in full sets, the side they are wanted for must invariably be specified.

In ordering valves covered by number 1 above, specify the name of the valve wanted, as these valves are of different sizes, though of the same type.
OIL CUPS.

Plate 56. EJUNCIDUS.

Ejusmodi . . . . 1. Cylinder Oiler in Cab, Baldwin style.
               (See Plates 77 and 78 for Sight Feed Cylinder Lubricators.)
Ekbetana . . . . 2. Oil Pipe Connection on Steam Chest.
Ekdemos . . . . 3. Condensing Oil Cup " " "
Ekelgeruch . . . . 4. Crosshead, Guide, or Connecting Rod Oil Cup (Needle style).
Ekellos . . . . 5. Crosshead, Guide, or Connecting Rod Oil Cup (Plunger style).
Ekevin . . . . 6. Rock Shaft Oil Cup.

In ordering numbers 4 or 5, it will be necessary to specify whether they are wanted for crossheads, guides, or rods.
GLASS WATER GAUGE.

Plate 57. EKIAM.

Eklektus ... 1. Upper Fitting.
Ekloge ... 2. Lower "
Ekmannite ... 3. Drain Valve.
Eknomos ... 4. Glass.
Ekrebel ... 5. Guard.
Ekron ... 6. Water Gauge Lamp Bracket.
ENGINEER'S BRAKE VALVE AND STEAM BRAKE PISTON.

Plate 58. EKSTERN.

Eksternest . . . Fig. 1.—Engineer's Brake Valve.

Eksteroog . . . 1. Disc Valve.
Elabitur . . . . 2. Valve Cover.
Elabor . . . . . 3. " Body.
Elaborab . . . . 4. Handle.

Elaborable . . . Fig. 2.—Steam Brake Piston.

Elaboracao . . . 5. Steam Brake Piston Rod.
Elaborados . . . 6. " " Piston.
Elaborammo . . 7. " " " Packing Rings.
Elaboraron . . . 8. " " " Follower.
Elaborassi . . . 9. " " " Nut.
STEAM GAUGE LAMP AND WATER GAUGE LAMP.

Plate 59. ELABORATE.

Elaboratio... Fig. 1.—Steam Gauge Lamp.
Elaboratus... Fig. 2.—Water " "

Elaborava... 1. Reservoir.
Elaborerai... 2. Burner.
Elacao... 3. Shade.
Elacatarum... 4. Base.
Elacaties... 5. Globe.
HEADLIGHT.

Plate 60. ELACHESTE.

Elachie . . . . 1. Case.
Elactesco . . . 2. Reflector.
Eladah . . . . 3. Glass.
Elaeodique . . 4. Chimney.
Elaeococca . . 5. Burner.
Elaeolithe . . 6. Reservoir.
WATER TANK.

Plate 61. ELAEOMETRE.

Elaeon ........ 1. Tank.
Elaeoptene ...... 2. Filling Funnel.
Elaeothese ...... 3. Funnel Lid.
Elaerine ........ 4. Valve Lifter.
Elaeusa ........ 5. " Wheel.
Elafro ........... 7. " Gooseneck.
Elagabal ........ 7A. " " Flange.
Elagabalus ....... 8. Handles.
Elagage ........ 9. Lugs.
TENDER FRAME, WOOD.

Plate 62. ELAHIOUN.

Elaidate . . . . 1. Truss Bar.
Elaidique . . . 2. " " Crosstie.
Elaiodic . . . . 3. Wedge Block or Chafing Casting.
Elaiodo . . . . 4. Front Draw Casting.
Elaiometer . . 5. Back " "
Elaique . . . . 6. Pushing Shoe.
Elaise . . . . . 7. Frame Washer.
Elambis . . . . 8. Longitudinal Draw Casting Bolt.
Elamene . . . . 9. Corner Bracket.
Elancais . . . . 10. Centre Pin.
Elancant . . . . 11. Safety Chain Hook.

Orders for centre pins should specify whether front or back are required when not for full sets.
TENDER FRAME, IRON.

Plate 63. ELANCEUR.

Elancons . . . . 1. Side Channel Bar.
Elanddier . . . . 2. Longitudinal Channel Bar.
Elangide . . . . 3. Transverse " "
Elangsuesco . . . . 4. " " " Strap.
Elahgueur . . . . 5. Corner Plate.
Elaolite . . . . 7. Side Bearing.
Elaopten . . . . 8. Brake Shaft Crosstie.
Elaphinis . . . . 10. Safety Chain Hanger.
Elaphocere . . . . 11. Front Draw Casting.
Elaphoide . . . . 12. Back " "
Elaphomyce . . . . 13. Chafing Casting.
Elaphro . . . . 15. Bolster Cap.
Elaphrope . . . . 16. Brake Clevis.
Elapidae . . . . 17. Tender Step.
Elapidatus . . . . 18. Brake Shaft Step.
Elapsion . . . . 20. Brace.

In ordering centre pins, observe the instructions for Plate 62.
TENDER TRUCK, WOOD.

Plate 64. ELAQUEATOS.

Elaqueatum . . . 1. Channel Bar.
Elargendo . . . 2. Top Bar of Frame.
Elargiamo . . . 3. Truss " " "
Elargimes . . . 4. Bottom " " "
Elargior . . . . 5. Wheel.
Elargiront . . . 6. Side Bearing.
Elargisco . . . 7. Frame Filling Piece.
Elargissi . . . . 8. Centre Plate.
Elargita . . . . 9. Truss "
Elargitus . . . 10. " Washer.
Elasmia . . . . . 13. Brake Clevis.

In ordering parts for a single truck, the order should specify whether they are wanted for front or back truck.
TENDER TRUCK, WROUGHT IRON.

Plate 65. ELASMOSE.

Elassesco . . . . 1. Frame.
Elassonyx . . . . 2. Crosstie.
Elasterio . . . . 3. " Brace.
Elastical . . . . 4. Pedestal.
Elasticity . . . . 5. " Cap.
Elasticos . . . . 6. Equalizing Beam.
Elastique . . . . 7. Spring.
Elatche . . . . 8. " Link.
Elatedness . . . 10. Centre Plate.
Elateius . . . . 11. Frame Filling Piece.
Elateridae . . . . 12. Side Bearing.
Elatine . . . . 15. Safety Chain Clevis.
Elationis . . . . 16. Spring Link Washer.

In ordering parts for a single truck, observe the instructions for Plate 64.
TENDER BRAKE WORK.

Plate 66. ELATOSTEMA.

Elatrabis . . . 1. Shaft.
Elatrabo. . . . 2. Handle.
Elatramus . . . 3. Hanger.
Elatrarem . . . 4. Step.
Elatras . . . . 5. Pawl.
Elautum . . . . 6. Ratchet.
Elavavi . . . . 7. Plate.
Elavavisti . . . 8. Eye Bolt.
Elaveuse . . . . 9. Beam.
Elavo . . . . . 10. Lever.
Elbae . . . . . 11. " Rod.
Elbeuvien . . . 13. Washer.
Elbidus . . . . . 15. Shoe.
APPARATUS FOR BURNING FUEL OIL.

Plate 67. ELBKAHN.

Elblachs . . . 1. Oil Injector.
Elbnachen . . 2. " Cock.
Elborum . . . 3. " " Shaft.
Elbow . . . . 4. " " " Handle.
Elbowed . . . 5. " " Quadrant.
Elbowing . . . 6. " Injector Steam Valve.
Elcaja . . . . 7. Fire Brick.
SELLERS INJECTOR, 1876.

Plate 68. ELCATE.

Elcathorax . . . 1. Delivery Tube.
Elcesaite . . . 2. Combining Tube.
Elciaro . . . . 3. Steam Nozzle.
Elcidrio . . . . 4. Valve on No. 7.
Elcisma . . . . 5. Solid Spindle.
Elcoma . . . . 6. Nut on Top of No. 5.
Elderitz . . . . 7. Hollow Spindle.
Elderly . . . . 8. Crosshead.
Eldership . . . 10. Lock Nut for No. 9.
Elderwort . . . 11. Follower on No. 26.
Eldest . . . . 12. Packing Rings under No. 11.
Eleagno . . . . 15. Link.
Eleanthe . . . 16. Knob on end of No. 28.
Eleasah . . . . 17. Lock Nut for No. 16.
Eleates . . . . 18. Nut on No. 29.
Eleatico . . . . 19. Plain Ring for Copper Pipe.
Eleaticus . . . 20. Check Valve.

(Continued on page 388 )
Plate 68, continued.

See page 386.

Eleatique . . . 23. Union to Pipes.
Eleazurus . . . 25. Lower Cylinder.
Elecampe . . . 26. Upper "
Eleccion . . . 28. Connecting Rod.
Elecciones . . 29. Waste Pipe.
Elecebra . . . 30. Screw Valve.
Elecebris . . . 31. Stuffing Box for No. 30.
Electamus . . . 32. Follower on No. 31.
Electarium . . . 33. Packing Rings under No. 32.
Electeur . . . . 34. Lever on No. 30.
Electicism . . . 35. Collar on No. 28.
Electilis . . . 36. Stud Bolts.
Electively . . 37. Pin through Nos. 9 and 15.
Electivite . . . 38. " " " 15 " 45.
Electorat . . . 39. " " " 28 " 34.
Electoress . . . 41. Pressure Foot.
Electrical . . . 42. Guide Rod.
Electricos . . . 43. Spring for No. 41.
Electrify . . . . 44. Latch.
Electrique . . . 45. Starting Lever.
Electrisch . . . 46. Funnel for Overflow.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.
For description of plate, see pages 390 and 391.
SELLERS INJECTOR, 1887.

Plate 69. ELECTRISE.

See page 389.

Electrode . . . . 1. Delivery Tube.
Electrum . . . . 2. Combining Tube.
Electuaire . . . . 3. Forcing Steam Nozzle.
Electuary . . . . 4. Lifting " "
Eleemosyna . . . . 5. Spindle Nut.
Eleescier . . . . 6. Stuffing Box for Spindle.
Elefanta . . . . 7. Spindle.
Elefantino . . . . 9. Collar on No. 10.
Elefas . . . . . . 10. Stuffing Box for Water Valve.
Elegamment . . 11. Follower for No. 6.
Elegantly . . . . 15. Links.
Elegaverim . . . . 16. Packing Ring in No. 10.
Elegavisti . . . . 17. Water Valve.
Elegeion . . . . 18. Ring in No. 17.
Elegendo . . . . 19. Plain Rings for Copper Pipe.
Eleggerei . . . . 20. Check Valve.
Eleggerla . . . 21. Valve Stem for No. 17.
Eleggono . . . 23. Plain Unions for Iron Pipes.
Elegiambic . . . 25. Injector Body.
Elegiast . . . 29. Waste Pipe.
Elegidas . . . 31. Cam for closing Waste Valve.
Elegidion . . . 32. Jam Nut for No. 29.
Elegidores . . . 33. Starting Lever.
Elegimos . . . 34. Lever on Cam Shaft.
Elegir . . . . . 35. Pin through No. 9 and No. 33.
Elegiremos . . . 36. Cam Shaft.
Elegisch . . . . 38. Index.
Elegiuzza . . . 39. Funnel for Overflow.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.
Plate 70.
**KORTING INJECTOR.**

**Plate 70. ELEGIVEL.**

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Elegorum</td>
<td>3. Side Rods, Right and Left.</td>
</tr>
<tr>
<td>Eleicao</td>
<td>4. Connecting Link and Pins.</td>
</tr>
<tr>
<td>Eleidis</td>
<td>5. Crosshead for Starting Shaft.</td>
</tr>
<tr>
<td>Eleison</td>
<td>7. Starting Shaft.</td>
</tr>
<tr>
<td>Eleito</td>
<td>8. Nuts for Starting and Overflow Shafts.</td>
</tr>
<tr>
<td>Eleituario</td>
<td>10. Lower Steam Valve.</td>
</tr>
<tr>
<td>Elektoral</td>
<td>11. Upper &quot; &quot;</td>
</tr>
<tr>
<td>Elektra</td>
<td>12. Lower &quot; Nozzle.</td>
</tr>
<tr>
<td>Eleleide</td>
<td>13. Upper &quot; &quot;</td>
</tr>
<tr>
<td>Elementado</td>
<td>14. Lower Water &quot;</td>
</tr>
<tr>
<td>Elementary</td>
<td>15. Upper &quot; &quot;</td>
</tr>
<tr>
<td>Elementen</td>
<td>16. &quot; Front Body Cap. (Also Lower.)</td>
</tr>
<tr>
<td>Elementos</td>
<td>17. Top and Bottom Body Caps.</td>
</tr>
<tr>
<td>Elemieira</td>
<td>19. Check Valve Complete.</td>
</tr>
<tr>
<td>Elemifere</td>
<td>20. Overflow Valve Complete.</td>
</tr>
</tbody>
</table>

(Continued on page 394.)
Plate 70, continued.

See page 392.

Elemina . . . 21. Overflow Stuffing Box.
Elemisalbe . 22. Followers for Stuffing Boxes.
Elemosina . 23. Nuts for Stuffing Boxes.
Elechical . 25. Connecting Links for Overflow Valve.
Elechorum . 27. Screws " " " " "
Elechos . . . 28. Bell Cranks for Overflow Valve.
Elentici . . 29. Coupling Nuts.
Elentique . . 31. Spanner Wrench.
Elend . . . . 32. Unions for Copper Pipe.
Elendbalg . . 34. Throttle Valve Stuffing Box.
Elender . . . 35. Nut for Stuffing Box.
Elendesten . 36. Follower for Stuffing Box.
Elendmeerr . 37. Spindle for Throttle Valve.
Elendrecht . . 38. Arm for Latch on Throttle Valve.
Elendshof . . 39. Latch.
Elendsring . . 40. Handle.
Elenhirsch . . 41. Washer.
Elenthier . . 42. Nut.
Eleocarpe . . 43. Adjusting Screw.
Eleocharis . . 44. Throttle Valve.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.

If injectors do not have the regulator M, the parts including Nos. 34 to 44 are not wanted, and plain valve and cap substituted. Cap No. 16. Lower Steam Valve No. 10.
For description of plate, see pages 396 and 397
MONITOR INJECTOR.

Plate 71. ELEODENDRE.

See page 395.

Eleodon... 1. Body (back part).
Eleogari... 2. " (front part).
Eleogoma... 4. Yoke.
Eleolate... 5. " Gland.
Eleolithe... 7. " Lock Nut.
Eleomeli... 8. Steam Valve Disc and Nut.
Eleoneme... 9. " " Spindle.
Eleonore... 10. " " Handle.
Eleontum... 11. " " Rubber Handle.
Eleophage... 12. " " Top Nut.
Eleopoli... 13. Jet Valve Disc and Nut.
Eleosponde... 14. " " Spindle.
Eleotesio... 15. " " Bonnet and Nut.
Eleothese... 16. " " Gland.
Eleozoma... 17. " " Lever Handle.
Eleozomus... 18. " " Top Nut.
Elephantia... 18a. " Tube.
Elephant... 18b. Lifting Nozzle.
Elephenor . . . . 19A. Eccentric Spindle.
Elephoro . . . . 20. Water Valve Bonnet.
Elesmatis . . . . 22. " " Spring.
Elesyces . . . . 23. " " Lever Handle.
Elettivo . . . . 25. Steam Nozzle.
Elettorato . . . . 27. Condensing "
Elettore . . . . 28. Delivery "
Elettriche . . . . 29. Swivel Pins.
Elettrico . . . . 30. Line Check.
Eleuchadio . . . . 31. " " Valve.
Eleulaleus . . . . 32. Stop Ring.
Eleusinian . . . . 33. Overflow Nozzle.
Eleusinius . . . . 33A. " Chamber with Nut.
Eleusippo . . . . 34. Heater Cock Check.
Eleusis . . . . 35. " " Bonnet and Nut.
Eleuthere . . . . 36. " " Spindle.
Eleutheria . . . . 37. " " T Handle.
Eleutherus. . . . . 38. Coupling Nut, Steam End.
Eleutho . . . . 38A. Tail Piece, " "
Elevacion . . . . 39A. Tail Piece, " "
Elevada . . . . 40. Coupling Nut, Delivery End.
Elevadico . . . . 40A. Tail Piece, " "

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.
ECLIPSE INJECTOR.

Plate 72. ELEVADOS.

Elevamento . . .  1. Handle of Regulating Valve.
Elevando . . . .  2. Small Nut holding in Stem.
Elevareis . . . .  3. Jam Nut.
Elevarem . . . .  4. Main Nut holding Injector in Shell.
Elevaremus. . . .  5. Stem.
Elevarono . . . .  7. Combining Tube.
Elevassem . . . .  8. Discharge Tube.
Elevassimo . . . .  9. Check Valve.
Elevateur . . . .  10. Space for Packing.
Elevatezza . . . .  11. Follower for confining Packing.
Elevatrice. . . . .  15. Body of Overflow Valve.
Elevavamo . . . .  16. Overflow Valve.
Elevavate . . . .  17. " " Spring.
Elevazione . . . .  18. Threaded End of Body.

In ordering parts for injector, give in all cases the maker’s number stamped on the injector. For code numbers, see pages 213 to 221.
Plate 73.

For description, see page 401

For description, see page 402.
LITTLE GIANT INJECTOR, "LOCOMOTIVE."

Plate 73. ELEVENTH.

Eleveranno . . . 1. Body.
Eleverebbe . . . 2. Stuffing Box.
Eleveremo . . . 3. Starting Lever.
Eleveresti . . . 4. Injector Lever.
Elevero . . . . 5. Right and Left Nut.
Eleverunt . . . 6. Starting Valve Body.
Eleves . . . . 7. Main Steam Valve.
Elevimus . . . 9. " " Stem.
Elevriez . . . 10. Starting Valve Link.
Elezionano . . . 11. Fulcrum.
Elezionare . . . 12. Stuffing Box Nut.
Elezionava . . . 13. Large Packing Nut.
Elezio . . . . 14. Small " "
Elfbladig . . . 15. Overflow Cap.
Elfdaagsch . . . 16. " Valve.
Elfdehalf . . . 17. " Nozzle.
Elfderlei . . . 18. Check Valve Stop.
Elfenbusch . . . 20. Swivel.
Elfenmaus . . . 21. Combining Tube Clamp.
Elfenspuk . . . 22. Quadrant.
Elfenweiss . . . 23. Thumb Screw.
Elferberg . . . . 24. Steam Tube.
Elfgesang . . . 25. Combining Tube.
Elfhoek . . . . 27. Check Valve.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.
LITTLE GIANT INJECTOR, 1889.

Plate 73. ELFHOEKIG.
See page 400.

Elfin . . . . . . 1. Body.
Elfjarig . . . . 2. Stuffing Box.
Elfmaal . . . . 3. Starting Lever.
Elfmeilig . . . . 4. Adjusting Wheel.
Elfpaarig . . . . 5. " " Stem.
Elfrank . . . . 6. " Stem Holder.
Elfreihig . . . . 7. Main Steam Valve.
Elfstijlig . . . . 9. " " Clamp.
Elftaegig . . . . 10. Starting Valve Link.
Elftal . . . . . 11. Fulcrum.
Elftnet . . . . 12. Stuffing Box Nut.
Elfvoud . . . . 13. Large Packing Nut.
Elfvoudig . . . . 14. Small " "
Elhanan . . . . 15. Overflow Cap.
Eliacus . . . . 16. " Valve.
Eliahba . . . . 17. " Nozzle.
Eliakim . . . . 18. Check Valve Stop.
Elisasph . . . . 20. Swivel.
Eliaishib . . . . 21. Combining Tube Clamp.
Eliaathah . . . . 22. Crosshead.
Eliberamus . . 23. Side Bars.
Eliberas . . . . 24. Steam Tube.
Elibero . . . . 25. Combining Tube.
Eliciano . . . . 27. Check Valve.

In ordering parts for injector, give in all cases the makers' number stamped on the injector. For code numbers, see pages 213 to 221.
Plate 74.

For description of plate, see page 404.
NATIONAL AND N. T. INJECTOR.

Plate 74. ELICIENDOS.
See page 403.

Elicited . . . 2. Cone.
Eliciting . . . 3. Stand Nut.
Elicito . . . . 4. Delivery Tube.
Elicosofia . . 5. Ram and Spindle.
Elicuerunt . . 6. Stand.
Eliuimus . . . 7. " Cap.
Elidemmo . . . 9. Water Valve.
Elidendo . . .10. Overflow Nozzle.
Elidesse . . .11. Delivery Tube Nut.
Elidevamo . .12. End Check Valve.
Elidevate . .13. Overflow Valve.
Eliezer . . .15. " Spindle.
Eligendi . . .17. " Lever.
Eligendos . .18. Stand of Water Valve.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.
Plate 75.

For description of plate, see pages 406 and 407.
METROPOLITAN DOUBLE TUBE LOCOMOTIVE INJECTOR.

Plate 75. ELIGERE.
See page 405.

Eligibly . . . . . . 1. Steam Valve Stem.
Eligieron . . . . . 2. Packing Nut for No. 1.
Eligius . . . . . . 3. Gland for No. 1.
Eligma . . . . . . 4. Steam Centre Piece.
Elihoreph . . . . . 5. " Swivel Ring.
Elihu . . . . . . 6. " Valve.
Elijamos . . . . . 7. Forcing Steam Tube.
Elikah . . . . . . 8. " Combining Tube.
Elimant . . . . . . 9. Line Check Ring.
Elimassem . . . . 10. " " Valve.
Elimasti . . . . . 11. Seat for Line Check.
Elimatius . . . . 12. Overflow Valve Stem.
Elimatos . . . . . 13. Auxiliary Steam Valve.
Elimberis . . . . . 15. Overflow Valve.
Eliminammo . . . . 17. " Centre Piece.
Eliminamos . . . . 18. Regulating Valve Handle Nut.
Eliminant . . . . 19. " " Wheel Disc.
Eliminaron . . . . 20. " " Wheel.
Eliminassi . . . . . 21. " " Stem.
Eliminatum . . . . 22. Packing Nut for No. 21.
Eliminava . . . . 23. Regulating Valve Centre Piece.
Eliminiez . . . . 24. Lifting Steam Tube.
Eliminons . . . . 25. " " Combining Tube.
Elimpidas . . . . 27. Lever Nut.
Elimpidavi . . . . 28. " " Rod.
Elimpido. . . . 29. " " Handle.
Elingo . . . . 30. Lever.
Elinguamus . . . . 31. Connecting Link.
Elinguatio . . . . 32. Fulcrums.
Elinguavi . . . . 33. Nuts for Stems Nos. 1 and 12.
Elinguibus . . . . 34. Lever Bolts.
Elinguid . . . . 35. Fulcrum Bolt.
Elinxerunt. . . . 36. Union Nut, Steam End.
Elinxi . . . . 37. Tail Pipe, " "
Eliocarpo . . . . 38. " " Suction "
Eliocometa . . . . 39. Union Nut, " "
Eliocroca . . . . 40. Tail Pipe, Delivery "
Eliofobia . . . . 41. Union Nut, " "
Eliolite. . . . . 42. Nut for Bolt No. 34.
Eliometro . . . . 43. " " " " 35.
Elionure . . . . 44. Overflow Funnel.
Elioscopio . . . . 45. Pin for Auxiliary Steam Valve.
Eliose . . . . 47. Overflow Valve Seat.
Eliostato. . . . . 48. " " Cap.
Eliota . . . . 49. Disc for Overflow Valve Seat.
Eliotropia . . . . 50. Lever Stop.
Eliphalet. . . . . 51. Body Bolt.
Elipsoide . . . . 52. Nut for same.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages 213 to 221.
BELFIELD INJECTOR.

Plate 76. ELIQUAMENT.

Eliquati. . . . 1. Injector Body.
Eliquation . . 2. Coupling Nut.
Eliqueiscis. . . 3. Swivel for Iron Pipe.
Eliqueesco . . . 3A. " " Copper Pipe.
Eliquia . . . . 4. Stuffing Box for Starting Stem.
Eliquium . . . . 5. Gland in No. 4.
Elirait . . . . . 6. Nut for No. 4.
Eliront . . . . 7. Regulating Valve.
Elisabeth . . . 8. Nut for No. 10.
Elisachar . . . 10. Regulating Plug Stuffing Box.
Elisaeus . . . 11. " Plug.
Eliserunt . . . 13. Pawl.
Elishamah . . 15. Lifting Tube.
Elishaphat . . 16. First Steam Nozzle.
Elisheba . . . 17. " Combining Tube.
Elision . . . . 18. Second " "
Elisirvite . . . 20. Check Valve.

(Continued on page 410.)
Plate 76, continued.

See page 408.

Elisisti . . . 22. Quadrant.
Elisor . . . 23. Overflow Nozzle.
Elissaeo . . 25. Link.
Elisseen . . 27. Bolt through No. 25 and No. 26.
Elitraria . . 28. Pin and Cotter through No. 24 and No. 25.
Elitrocele . . 29. Pin and Cotter through No. 24 to move Rod No. 46.
Elittiche . . 30. Crosshead on No. 31.
Elittico . . 31. Starting Stem.
Elixacao . . 32. " Valve.
Elixamus . . 33. Lock Nut to Connect No. 15 to No. 31.
Elixate . . . 34. Lever on Overflow Valve.
Elixation . . 35. Stem for " "
Elixatura . . 36. Nut to Connect No. 35 to No. 37.
Elixaturis . . 37. Overflow Valve.
Elixing . . . 38. Nut for No. 41.
Elixorum . . 41. Overflow Valve Stuffing Box.
Elixura . . . 42. Pin through No. 34 and No. 46.
Elizaphan . . 43. Knob on Rod No. 46.
Eliziario . . 44. Lock Nut to hold No. 43.
Elizur . . . 45. Stop on No. 46 to open Overflow Valve.
Eljen . . . 46. Overflow Valve Rod.

In ordering parts for injector, give in all cases the maker's number stamped on the injector. For code numbers, see pages, 213 to 221.
Plate 77.

NATHAN SIGHT FEED CYLINDER LUBRICATOR.

For description of plate, see page 412.
NATHAN SIGHT FEED CYLINDER LUBRICATOR.

Plate 77. ELKAITE.

See page 411.

Elkander . . . . 1. Condenser.
Elkesaite . . . . 2. Filling Plug.
Elkosh . . . . 3. Auxiliary Oiler.
Ellagique . . . . 4. Safety Valve.
Ellagite . . . . 5. Reducing Plug.
Ellanodici . . . . 5A. Blow-off "
Ellasar . . . . 6. Delivery Nut and Coupling.
Ellbogen . . . . 7. Water Valve.
Ellbuth . . . . 8. Stud Nut.
Elleboog . . . . 9. Sight Feed Glass.
Elleborina . . . . 10. Upper Sight Bracket and Nut.
Ellemaat . . . . 11. Lower " " " "
Elleni . . . . 15. Upper Gauge Bracket and Nut.
Elleniche . . . . 16. Lower " " " "
Ellenico . . . . 17. Waste Cock.
Ellenijker . . . . 18. Regulating Valve.
Plate 78.

DETROIT SIGHT FEED CYLINDER LUBRICATOR.

For description of plate, see page 414.
DETROIT SIGHT FEED CYLINDER LUBRICATOR.

Plate 78. ELLENPRINZ.

See page 413.

Ellenstab . . . 1. Condenser.
Ellenwaare . . 2. Filler Plug.
Ellenzahl . . . 3. Auxiliary Oiler.
Ellepijp . . . . 4. Connection for Boiler Pressure.
Ellepijpen . . . 5. Plugs to fill Glasses with Water when Lubricator is first attached.
Elleridder . . . 6. Tail Pipe.
Ellerina . . . . 7. Water Valve.
Ellesque . . . . 8. Jam Nut.
Ellewaar . . . . 9. Sight Feed Glass.
Ellewinkel . . 10. Drain Valve.
Ellicott . . . . 11. Regulating Valve.
For description of plate, see page 416.
METALLIC PISTON ROD PACKING.

Plate 79. ELLINGE.

See page 415.

---

**Fig. 1.—Ellinger.**

**Fig. 2.—Ellingerry.**

Ellipanche . . 1. Packing Case.
Ellipsaire . . 2. Ball Joint.
Ellipsis . . . 3. Vibrating Cup.
Ellipsoid . . 4. Babbitt Ring.
Elliptical . . 5. " "
Elliptico . . 6. Follower.
Elliptisch . . 7. Coil Spring.
Ellisia . . . 8. Stuffing Box.
Ellissoide . . 9. Copper Wire Joint.
Ellkatze . . 10. Neck Ring.
Ellobie . . . 11. Swab Holder.
Ellwand . . . 12. Oil Cup Bracket.
Ellychnie . . 13. " Cup.

In ordering repairs, give in all cases the number stamped on packing case.
Plate 80.

For description of plate, see page 418.
METALLIC VALVE STEM PACKING.

Plate 8o. ELLYCHNIUM.

(See page 417.)

Fig. 1.—Ellychnor.

Fig. 2.—Ellychnoty.

Elmakin... 1. Packing Case.
Elmigere... 2. Ball Joint.
Elminti... 3. Vibrating Cup.
Elmintiasi... 4. Babbitt Ring.
Elmintico... 5. “ “
Elminzia... 6. Follower.
Elmodam... 7. Coil Spring.
Elmsfeuer... 8. Stuffing Box.
Elmsley... 9. Copper Wire Joint.
Elocandi... 10. Bushing.
Elocandum... 11. Swab Holder.
Elocavimus... 12. Oil Cup Bracket.
Elocavisti... 13. “ Cup.
Elocher... 14. Preventer.

In ordering repairs, give in all cases the number stamped on packing case.
SPECIFICATION CODE.

In addition to the foregoing code words for parts of locomotives, the following code words are provided for use in connection therewith, or to express details of specifications for locomotives:

Prozaisch . . Steel boiler, steel fire box, iron flues, No. 12 wire gauge.
Prozastijl . . Steel tires.
Prozent . . . Steel wrist pins.
Prozenten . . Hammered iron wrist pins.
Prozoïque . . Iron stay bolts.
Prude . . . Fire-brick arch for bituminous coal burning locomotives.
Prudement . . Dry pipe of wrought iron.
Prudencial . . Dry pipe, copper.
Prudencio . . Stack, grates, and smoke box to suit fuel.
Prudente . . . Chilled cast iron engine truck wheels.
Prudently . . Wrought centre, steel tired engine truck wheels.
Prudenza . . . Automatic sight feed lubricator for cylinders.
Pruderie . . . Piston rods of iron.
Prudish . . . Piston rods of steel.
Prudishly . . Guides of steel.
Prudore . . . Guides of cast iron.
Pruebes . . . Guides of wrought iron, case hardened.
Pruefbar . . . Crossheads of cast iron.
Pruefen . . . Crossheads of steel.
Prueffling . . Slide valves, plain —— pattern.
Pruefstein . . Slide valves, balanced pattern.
Pruefung . . . Axles of hammered iron.
Pruefungen . . Axles of steel.
Pruefzeit . . . Metallic packing for piston rods and valve stems.
Pruegeln . . . Cab of wood.
Prueggiano . . Cab of iron.
Prueggiare . . Cab to have double roof with air-space between, and ventilator in roof.
Prueggiava . . Spring buffers, front and back.
Prueggio . . . Pilot of wood, braced with iron.
Prugnolo . . . Guard rails, front and back.
Pruido . . . Furniture: Engine to be furnished with one sand
box (two sand boxes for larger size tank en-
gines), stand for head lamp, two whistles,
blow-off cock, blower and safety valves, steam
gauge, cab lamp, two glass water gauges with
lamps; also a complete set of tools, consisting
of two traversing screw jacks and ievers, one
heavy pinch bar with steel point and heel,
complete set of wrenches to fit all nuts and
bolts on engine, including two monkey
wrenches, one set of driving box packing tools,
one machinist's hammer, one soft hammer,
three cold chisels (two flat and one cape), one
long spout quart oil can, one two gallon oil
can, one tallow pot, one torch, engineer's arm
rest, one extra fusible plug, signal gong, cab
seats, cab seat cushions, one poker, one scraper,
one slice bar, and one scoop shovel.

Pruikebol . . Headlight, with silvered reflector.
Pruikedoos . . Three 8" bull's eyes, with red, white, and green
lenses.

Pruikenet . . Finish: Cylinders lagged with same material as
boiler, and neatly cased with iron, painted.
Cylinder head covers of hydraulic forged steel,
painted or polished. Steam chests with cast
iron tops; bodies cased with iron, painted.
Dome lagged with same material as boiler, with
painted iron casing on body and cast iron top
and bottom rings.

Pruikerig . . Boiler lagged with sectional magnesia.
Pruijkjes . . Boiler lagged with sectional asbestos.
Pruilmond . . Jacket secured by iron bands.
Pruimmedant . Hand rails of iron.
Pruimensap . Running boards of iron, with nosings of iron.
Pruimers . . Wheel cover nosings of iron.
Pruinaram . . Wheel cover nosings of brass.
Pruinose . . . Engine and tender to be well painted and varnished. Lettering and numbering to be as specified by purchaser.

Pruinosos . . . General features of construction.
Pruir . . . . All finished movable nuts and all wearing surfaces of valve motion made of steel, or iron case hardened.
Pruivel' . . . All wearing brasses made of phosphor bronze.
Prulachtig . . All wearing brasses made of ingot copper and tin, alloyed in proportion to give best mixture for wearing bearings.
Prullig . . . All threads on bolts to United States standard.
Prumnides . . Tender: Tank of steel strongly put together, with angle iron corners and well braced.
Prumo . . . . Tender frame substantially built of channel iron, strongly braced; floor of iron.
Prumulace . . Tender trucks made with wrought iron, equalized frames; springs, crucible cast steel, tempered in oil.
Prunaia . . . Wheels of chilled cast iron.
Pruneaux . . Hand brake on all tender wheels.
Prunelaies . . Metallic brake beams.
Prunella . . . Tool boxes of iron, fitted with locks and keys.

The details above mentioned refer to the usual practice of the Works, for export locomotives. Code words are provided for special details of construction, as follows:

Pruniforme . . Automatic bell ringer.
Pruning . . . Baldwin Locomotive Works steam brake.
Prunkbett . . Steam brake on two pairs of driving wheels.
Prunkhalle . . Steam brake on three pairs of driving wheels.
Prunkloser . . Steam brake on four pairs of driving wheels.
Prunkspiel . . Steam brake on tender.
Prunksucht . . Hand screw brake, to operate on steam brake.
Prunkvoll . . American Brake Company's steam brake on two pairs of driving wheels.
Prunkwerk . . American Brake Company's steam brake, equalized
pressure on forward side of two pairs of driving wheels.

**Prunophore** . American Brake Company's steam brake, equalized pressure on forward side of three pairs of driving wheels.

**Prunosa** . American Brake Company's steam brake, equalized pressure on forward side of four pairs of driving wheels.

**Prunulis** . American Brake Company's steam brake, equalized pressure on forward side of five pairs of driving wheels.

**Prunulorum** . American Brake Company's steam brake on tender.

**Pruriebat** . Westinghouse quick action automatic air brake.

**Pruriente** . Westinghouse quick action automatic air brake on two pairs of driving wheels.

**Prurigem** . Westinghouse quick action automatic air brake on two pairs of driving wheels and tender.

**Prurigine** . Westinghouse quick action automatic air brake, equalized pressure on forward side of three pairs of driving wheels only.

**Pruriginis** . Westinghouse quick action automatic air brake, equalized pressure on forward side of four pairs of driving wheels only.

**Pruriosi** . Westinghouse quick action automatic air brake, equalized pressure on forward side of five pairs of driving wheels only.

**Pruriosos** . Westinghouse quick action automatic air brake, equalized pressure on forward side of three pairs of driving wheels and tender.

**Pruriteux** . Westinghouse quick action automatic air brake, equalized pressure on forward side of four pairs of driving wheels and tender.

**Pruritivi** . Westinghouse quick action automatic air brake, equalized pressure on forward side of five pairs of driving wheels and tender.

**Pruritivos** . Westinghouse train signal.

**Prusaeus** . Westinghouse vacuum brake.

**Prusensium** . Westinghouse vacuum brake on tender wheels only (including ejector and diaphragms).
Prusiacus . . Westinghouse vacuum brake on two pairs of driving wheels only.
Prusianos . . Westinghouse vacuum brake on forward side of two pairs of driving wheels only.
Prusica . . Westinghouse vacuum brake on tender and forward side of two pairs of driving wheels.
Prusicos . . Westinghouse vacuum brake on forward side of three pairs of driving wheels only.
Prussian . . Westinghouse vacuum brake on tender and forward side of three pairs of driving wheels.
Prussiates . . Westinghouse vacuum brake on forward side of four pairs of driving wheels only.
Prussico . . Westinghouse vacuum brake on tender and forward side of four pairs of driving wheels.
Prussique . . Westinghouse vacuum brake on forward side of five pairs of driving wheels only.
Prutenic . . Westinghouse vacuum brake on tender and forward side of five pairs of driving wheels.
Pruttelig . . Eames vacuum brake.
Prutzeln . . Eames vacuum brake on tender and train wheels only.
Pryest . . . . Eames vacuum brake on two pairs of driving wheels only.
Pryingly . . Eames vacuum brake on two pairs of driving wheels and tender.
Prymnesia . . Eames vacuum brake on forward side of two pairs of driving wheels only.
Prymnesium . Eames vacuum brake on tender and forward side of two pairs of driving wheels.
Prymnessos . Eames vacuum brake on forward side of three pairs of driving wheels only.
Prymnesus . . Eames vacuum brake on tender and forward side of three pairs of driving wheels.
Prytanee . . . Eames vacuum brake on forward side of four pairs of driving wheels only.
Prytaneion . . Eames vacuum brake on tender and forward side of four pairs of driving wheels.
Psacum . . . . English (Vacuum Brake Company's) automatic vacuum brakes.
Psadiroma . English automatic vacuum brake ejector for operating train brakes only.
Psaliceres . English automatic vacuum brake ejector for tender wheels only.
Psalio . English automatic vacuum brake ejector for four driving wheels and tender, outside equalized pressure.
Psallebat . English automatic vacuum brake ejector for four driving wheels only, outside equalized pressure.
Psallendum . English automatic vacuum brake ejector for six driving wheels and tender, outside equalized pressure.
Psallerunt . English automatic vacuum brake ejector for six driving wheels only, outside equalized pressure.
Psallette . English automatic vacuum brake ejector for eight driving wheels and tender, outside equalized pressure.
Psallidies . English automatic vacuum brake ejector for eight driving wheels only, outside equalized pressure.
Psallimus . English automatic vacuum brake ejector for ten driving wheels and tender, outside equalized pressure.
Psalliisti . English automatic vacuum brake ejector for ten driving wheels only, outside equalized pressure.
Psallunt . English (Vacuum Brake Company's) non-automatic vacuum brakes.
Psalm . English non-automatic vacuum brake ejector for operating train brakes only.
Psalmata . English non-automatic vacuum brake ejector for tender wheels only.
Psalmboek . English non-automatic vacuum brake ejector for four driving wheels and tender, outside equalized pressure.
Psalmbuch . English non-automatic vacuum brake ejector for four driving wheels only, outside equalized pressure.
Psalmear . English non-automatic vacuum brake ejector for six driving wheels and tender, outside equalized pressure.
Psalmicen . English non-automatic vacuum brake ejector for six driving wheels only, outside equalized pressure.
Psalmicini. English non-automatic vacuum brake ejector for eight driving wheels and tender, outside equalized pressure.

Psalmique. English non-automatic vacuum brake ejector for eight driving wheels only, outside equalized pressure.

Psalmista. English non-automatic vacuum brake ejector for ten driving wheels and tender, outside equalized pressure.

Psalmistis. English non-automatic vacuum brake ejector for ten driving wheels only, outside equalized pressure.

Psalmodiari. Screw brake.

Psalmodize. Hand screw brake on two pairs of driving wheels.

Psalter. Hand screw brake on three pairs of driving wheels.


Psamethos. Brass dome casing.

Psamenit. Brass steam chest casing.

Psametico. Brass case chronometer lever marine clock.

Psammathus. Driving boxes of brass.

Psamocole. Driving boxes of cast steel.

Psamode. Driving boxes of wrought iron.

Psamodus. Fire box, Belpaire pattern.

Psamogene. Fire box of copper.

Psamolepe. Fire brick supported on water tubes instead of angle irons or studs.

Psamures. Sliding fire door.

Psaphis. Copper tubes.

Psaphon. Brass tubes.

Psaranorum. Copper tubes, 1½" diameter, No. 13 wire gauge, 1.63 pounds per foot.

Psaranos. Copper tubes, 1½" diameter, No. 12 wire gauge, 1.85 pounds per foot.

Psararanum. Copper tubes, 1½" diameter, No. 11 wire gauge, 2.02 pounds per foot.

Psarisome. Copper tubes, 1¾" diameter, No. 10 wire gauge, 2.24 pounds per foot.

Psaroide. Copper tubes, 1¾" diameter, No. 13 wire gauge, 1.92 pounds per foot.

Psarolite. Copper tubes, 1¾" diameter, No. 12 wire gauge, 2.18 pounds per foot.
Psaronio . . . Copper tubes, 1 3/4" diameter, No. 11 wire gauge, 2.39 pounds per foot.
Psaronites . . . Copper tubes, 1 3/4" diameter, No. 10 wire gauge, 2.65 pounds per foot.
Psarophole . . . Copper tubes, 2" diameter, No. 13 wire gauge, 2.21 pounds per foot.
Psathyrose . . . Copper tubes, 2" diameter, No. 12 wire gauge, 2.51 pounds per foot.
Psatura . . . Copper tubes, 2" diameter, No. 11 wire gauge, 2.75 pounds per foot.
Psautier . . . Copper tubes, 2" diameter, No. 10 wire gauge, 3.06 pounds per foot.
Pseboa . . . Copper tubes, 2 1/4" diameter, No. 13 wire gauge, 2.50 pounds per foot.
Psecade . . . Copper tubes, 2 1/4" diameter, No. 12 wire gauge, 2.85 pounds per foot.
Psecadies . . . Copper tubes, 2 1/4" diameter, No. 11 wire gauge, 3.12 pounds per foot.
Psecfororia . . . Copper tubes, 2 1/4" diameter, No. 10 wire gauge, 3.46 pounds per foot.
Pselaphes . . . Brass tubes, 1 1/2" diameter, No. 13 wire gauge, 1.63 pounds per foot.
Pselchis . . . Brass tubes, 1 1/2" diameter, No. 12 wire gauge, 1.85 pounds per foot.
Pselions . . . Brass tubes, 1 1/2" diameter, No. 11 wire gauge, 2.02 pounds per foot.
Pseliumene . . . Brass tubes, 1 1/2" diameter, No. 10 wire gauge, 2.24 pounds per foot.
Psellisme . . . Brass tubes, 1 3/4" diameter, No. 13 wire gauge, 1.92 pounds per foot.
Psellismus . . . Brass tubes, 1 3/4" diameter, No. 12 wire gauge, 2.18 pounds per foot.
Psenerus . . . Brass tubes, 1 3/4" diameter, No. 11 wire gauge, 2.39 pounds per foot.
Psephisme . . . Brass tubes, 1 3/4" diameter, No. 10 wire gauge, 2.65 pounds per foot.
Psephite . . . Brass tubes, 2" diameter, No. 13 wire gauge, 2.21 pounds per foot.
Psephobole . . . Brass tubes, 2" diameter, No. 12 wire gauge, 2.51 pounds per foot.
Psepholax . . Brass tubes, 2" diameter, No. 11 wire gauge, 2.75 pounds per foot.
Pseques . . . Brass tubes, 2" diameter, No. 10 wire gauge, 3.06 pounds per foot.
Psetta . . . . Brass tubes, 2 1/4" diameter, No. 13 wire gauge, 2.50 pounds per foot.
Psettarum . . Brass tubes, 2 1/4" diameter, No. 12 wire gauge, 2.85 pounds per foot.
Psettis . . . . Brass tubes, 2 1/4" diameter, No. 11 wire gauge, 3.12 pounds per foot.
Pseudalees . . Brass tubes, 2 1/4" diameter, No. 10 wire gauge, 3.46 pounds per foot.
Pseudarade . . Iron tubes.
Pseudaspis . . Iron tubes, 1 1/2" diameter, No. 13 wire gauge.
Pseudoechis . . Iron tubes, 1 1/2" diameter, No. 12 wire gauge.
Pseudelaps . . Iron tubes, 1 1/2" diameter, No. 11 wire gauge.
Pseuderyx . . Iron tubes, 1 1/2" diameter, No. 10 wire gauge.
Pseudoafia . . Iron tubes, 1 3/4" diameter, No. 11 wire gauge.
Pseudoasma . . Iron tubes, 1 3/4" diameter, No. 10 wire gauge.
Pseudocato . . Iron tubes, 2" diameter, No. 13 wire gauge.
Pseudocoia . . Iron tubes, 2" diameter, No. 12 wire gauge.
Pseudodox . . Iron tubes, 2" diameter, No. 11 wire gauge.
Pseudogyne . . Iron tubes, 2" diameter, No. 10 wire gauge.
Pseudolien . . Iron tubes, 2 1/4" diameter, No. 13 wire gauge.
Pseudology . . Iron tubes, 2 1/4" diameter, No. 12 wire gauge.
Pseudome . . . . Iron tubes, 2 1/4" diameter, No. 11 wire gauge.
Pseudomeno . . Iron tubes, 2 1/4" diameter, No. 10 wire gauge.
Pseudomys . . Copper ends brazed on iron tubes.
Pseudonymo . . Frames outside of driving wheels.
Pseudornis . . Glass water gauge on tender.
Pseudosmia . . Extra headlight, in addition to one headlight or three bull’s eyes.
Pseudova . . . Oil cups on driving boxes.
Pseudovum . . Brass piston rod and valve stem glands.
Pseudozene . . Brass throttle valve seat.
Paeustes . . . Extra pilot.
Pshaw . . . . . Piston rods extended through front cylinder heads.
Psiadia . . . Retaining rings for driving wheels.
Psiche . . . Belpaire combined screw and lever reverse gear.
Psichico . . . Side rods, I section, for two pairs of driving wheels.
Psichine . . . Side rods, I section, for three pairs of driving wheels.
Psicoda . . . Side rods, I section, for four pairs of driving wheels.
Psicologia . . Side rods, I section, for five pairs of driving wheels.
Psicologo . . Main rods, I section.
Psicrotico . . Steam or air sanding devices.
Psilarum . . . Piston slide valves.
Psiletes . . . Boyer speed recorder.
Psillo . . . Copper steam pipes in smoke box.
Psilobon . . . Copper stay bolts.
Psilopogon . . Roof over forward part of tender.
Psilothe . . . American open hearth tires.
Psilothris . . Vicker's tires.
Psilothron . . Krupp open hearth tires.
Psilothrum . . Krupp crucible tires.
Psophode . . Tender fitted with water scoop, for taking water from track tanks while running.
Psophodum . . Steel tired tender wheels, with wrought iron spoke or plate centres instead of chilled cast iron wheels.
Psoricorum . . Wheel centres.
Psoriforme . . Driving wheel centres of wrought iron.
Psorique . . . Driving wheel centres of cast steel.
Psychical . . Wrecking frogs.
# INDEX

<p>| Abt System of Rack-Rail Locomotive (with Illustration) | 80, 84, 85 |
| Addenda | 163 |
| Adhesion, Device for Increasing | 20 |
| Adhesion of Compound Locomotives | 163 |
| Adoption of the Link Motion | 54 |
| Advantages of Compounding | 147 |
| Advertisement, Time Table | 13 |
| Africa, First Locomotive for | 81 |
| Air-Spring for Locomotives | 34 |
| Altoona and Phillipsburg Connecting Railroad, Passenger Compound (Illustration) | 147 |
| Altoona, Clearfield and Northern, Ten-Wheel Compound (Illustration) | 181 |
| American Homogeneous Cast Steel Used | 58 |
| &quot;American&quot; Type Locomotive First Used | 39 |
| Apparatus for burning Fuel Oil (with Illustration) | 385 |
| Arrangement of Fire Bricks in Fire Box (with Illustration) | 259 |
| Arrangement of Starting Valves and Cylinder Cocks for Compound Locomotive (with Illustration) | 273 |
| Atlantic Avenue Railway Motor | 70 |
| &quot;Atlantic&quot; Type Locomotive (with Illustration) | 83, 86, 87 |
| Austin, William L., Partnership | 77 |
| Austria, Locomotive for | 28 |
| Autofogasta Railway, Locomotive with Outside Frames | 78 |
| Averill Coal and Oil Company Narrow-Gauge Locomotive | 65 |
| Axle, Driving (with Illustration) | 231, 285 |
| Back Cylinder Casing Cover | 230 |
| Back Cylinder Head | 229 |
| Back Draw Bar | 234 |
| Back Draw Casting, Tender | 235 |
| Bahia Extension, Freight Compound (Illustration) | 149 |
| Baird, Mathew, Partnership | 45 |
| Baldwin Compound Cylinders (with Illustration) | 149, 265, 267 |
| Baldwin Compound Cylinders and Attachments (with Illustration) | 151, 177, 260 |
| Baldwin Locomotive Works, M. Baird &amp; Company | 62 |</p>
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baldwin, M. W.</td>
<td>7</td>
</tr>
<tr>
<td>Baldwin, M. W., Death of</td>
<td>60</td>
</tr>
<tr>
<td>Baldwin, Vail &amp; Hufty</td>
<td>25</td>
</tr>
<tr>
<td>Baltimore and Ohio, Passenger. (Illustration)</td>
<td>85</td>
</tr>
<tr>
<td>Baltimore and Ohio Railroad, Eight-Wheel Connected Locomotive</td>
<td>42</td>
</tr>
<tr>
<td>Bar Iron, Test Specification</td>
<td>95</td>
</tr>
<tr>
<td>Barrus, Geo. H., Method of Combining Cards (with Illustration)</td>
<td>171</td>
</tr>
<tr>
<td>Belfield Injector (with Illustration)</td>
<td>409</td>
</tr>
<tr>
<td>Bell (with Illustration)</td>
<td>232, 323</td>
</tr>
<tr>
<td>Belmont, August, Austrian Locomotive</td>
<td>28</td>
</tr>
<tr>
<td>Bissell, Levi, Air-Spring</td>
<td>34</td>
</tr>
<tr>
<td>Bissell Truck First Used, 1861</td>
<td>57</td>
</tr>
<tr>
<td>“Black Hawk” Locomotive, Philadelphia and Trenton Railroad</td>
<td>21</td>
</tr>
<tr>
<td>Blower Valve</td>
<td>233, 361</td>
</tr>
<tr>
<td>Blow-off Cock</td>
<td>234, 361</td>
</tr>
<tr>
<td>Boiler</td>
<td>229</td>
</tr>
<tr>
<td>Boiler and Attachments (with Illustration)</td>
<td>256</td>
</tr>
<tr>
<td>Boiler and Fire Box Steel, Test Specification</td>
<td>93</td>
</tr>
<tr>
<td>Boiler, Efficiency obtained in Compound Locomotives</td>
<td>164</td>
</tr>
<tr>
<td>Boiler Iron, Test Specification</td>
<td>93</td>
</tr>
<tr>
<td>Boiler Jacket</td>
<td>229</td>
</tr>
<tr>
<td>Boiler Jacket Bands</td>
<td>229</td>
</tr>
<tr>
<td>Boiler Lagging</td>
<td>229</td>
</tr>
<tr>
<td>Boiler Plugs</td>
<td>229, 257</td>
</tr>
<tr>
<td>Boiler, Tests Specification</td>
<td>93</td>
</tr>
<tr>
<td>Boiler Tubes</td>
<td>229</td>
</tr>
<tr>
<td>Boiler Tube, Test Specification</td>
<td>94</td>
</tr>
<tr>
<td>Boiler Tube Ferrules</td>
<td>229</td>
</tr>
<tr>
<td>Boilers, Straight, with Two Domes</td>
<td>55</td>
</tr>
<tr>
<td>Boring Tools for Valve Bushings</td>
<td>162</td>
</tr>
<tr>
<td>Borst, W. W., Performance of Narrow-Gauge Locomotives</td>
<td>66</td>
</tr>
<tr>
<td>Brake Cylinder</td>
<td>234, 343, 345</td>
</tr>
<tr>
<td>Brake Heads, Driving</td>
<td>234, 343, 345</td>
</tr>
<tr>
<td>Brake Heads, Tender</td>
<td>235, 383</td>
</tr>
<tr>
<td>Brake Shoes, Driving</td>
<td>234, 343, 345</td>
</tr>
<tr>
<td>Brake Shoes, Tender</td>
<td>235, 383</td>
</tr>
<tr>
<td>Brake Valve, Engineer’s (with Illustration)</td>
<td>367</td>
</tr>
<tr>
<td>Brake Work, Steam Driving (with Illustrations)</td>
<td>343, 345</td>
</tr>
<tr>
<td>Brake Work, Tender (with Illustration)</td>
<td>383</td>
</tr>
<tr>
<td>“Brandywine” Locomotive, Philadelphia and Columbia Railroad</td>
<td>21</td>
</tr>
<tr>
<td>Brass and Copper Pipe, Test Specification</td>
<td>95</td>
</tr>
<tr>
<td>Brass Tires used on the “Brandywine”</td>
<td>21</td>
</tr>
<tr>
<td>Brasseyes, Rod (with Illustration)</td>
<td>232, 304</td>
</tr>
<tr>
<td>Brazilian Industrial Improvement Company, Mogul Compound. (Illustration)</td>
<td>183</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Broken Packing Rings</td>
<td>163</td>
</tr>
<tr>
<td>Brooklyn Wharf and Warehouse Co. Enclosed Compound. (Illustration)</td>
<td>165</td>
</tr>
<tr>
<td>Bull Nose, Pilot</td>
<td>233, 317</td>
</tr>
<tr>
<td>Bumper and Attachments, Back (with Illustration)</td>
<td>327</td>
</tr>
<tr>
<td>Bumper and Attachments, Front (with Illustration)</td>
<td>315, 317</td>
</tr>
<tr>
<td>Burnham, George, Partnership</td>
<td>62</td>
</tr>
<tr>
<td>Burnham, George, Jr., Partnership</td>
<td>85</td>
</tr>
<tr>
<td>Burnham, Parry, Williams &amp; Co., New Firm</td>
<td>68</td>
</tr>
<tr>
<td>Burning Anthracite Coal</td>
<td>24</td>
</tr>
<tr>
<td>Bushing for Compound Cylinder (with Illustration)</td>
<td>153, 271</td>
</tr>
<tr>
<td>Bushings, Removal of Old</td>
<td>162</td>
</tr>
<tr>
<td>Cab</td>
<td>235</td>
</tr>
<tr>
<td>Cab Bracket</td>
<td>234, 327</td>
</tr>
<tr>
<td>Cab Bracket Plate</td>
<td>234, 327</td>
</tr>
<tr>
<td>Cab Cylinder Oilier, B. L. W. Style</td>
<td>234, 363</td>
</tr>
<tr>
<td>Cab First Used</td>
<td>41</td>
</tr>
<tr>
<td>Cable Code Numbers</td>
<td>213</td>
</tr>
<tr>
<td>Cable Sentences</td>
<td>222</td>
</tr>
<tr>
<td>Cabling, Examples for</td>
<td>208</td>
</tr>
<tr>
<td>Cabling, Instructions for</td>
<td>207</td>
</tr>
<tr>
<td>Cam, Driving Brake</td>
<td>234</td>
</tr>
<tr>
<td>Camden and Amboy Railroad Company, Locomotive</td>
<td>9</td>
</tr>
<tr>
<td>Campbell, Henry R., Design of Locomotive</td>
<td>26</td>
</tr>
<tr>
<td>Canadian Pacific Ten-Wheel Compound. (Illustration)</td>
<td>172</td>
</tr>
<tr>
<td>Cannon, L. G., Extract from Letter</td>
<td>23</td>
</tr>
<tr>
<td>Cantagallo Railway</td>
<td>75</td>
</tr>
<tr>
<td>Capacity and Location</td>
<td>89</td>
</tr>
<tr>
<td>Casing, Cylinder</td>
<td>230, 263</td>
</tr>
<tr>
<td>Casing, Steam Chest</td>
<td>230, 263</td>
</tr>
<tr>
<td>Cathcart, Andrew, Design for Rack-Rail Locomotive</td>
<td>42</td>
</tr>
<tr>
<td>Centennial International Exhibition</td>
<td>69</td>
</tr>
<tr>
<td>Centennial Narrow-Gauge Railway</td>
<td>69</td>
</tr>
<tr>
<td>Central Dominican Mogul Compound. (Illustration)</td>
<td>181</td>
</tr>
<tr>
<td>Central Railroad of Georgia, Link Motion</td>
<td>53</td>
</tr>
<tr>
<td>Central Railroad of New Jersey, First Double-Ende Locomotive</td>
<td>67</td>
</tr>
<tr>
<td>Central Railroad of New Jersey, Test</td>
<td>200</td>
</tr>
<tr>
<td>Centre Pin Guide and Crosstie, Engine Truck (with Illustration.)</td>
<td>321</td>
</tr>
<tr>
<td>Centre Pin, Tender Frame</td>
<td>235</td>
</tr>
<tr>
<td>Centre Plate, Tender Truck</td>
<td>235</td>
</tr>
<tr>
<td>Chafling Casting, Tender</td>
<td>234</td>
</tr>
<tr>
<td>Changes and Improvements</td>
<td>24</td>
</tr>
<tr>
<td>Charleston and Hamburg Railroad Company, Locomotive &quot;Miller&quot;</td>
<td>15</td>
</tr>
<tr>
<td>Check, Injector</td>
<td>233, 359</td>
</tr>
<tr>
<td>Chicago, Burlington and Quincy Railroad. &quot;Atlantic&quot; Type</td>
<td>87, 199</td>
</tr>
<tr>
<td>Chicago, Milwaukee and St. Paul Railroad, Test</td>
<td>196</td>
</tr>
<tr>
<td>Chilean State Railways, Compound Freight. (Illustration)</td>
<td>176</td>
</tr>
<tr>
<td>Chilean State Railways Compound “American” Type. (Illustration)</td>
<td>192</td>
</tr>
<tr>
<td>Chilled Wheels First Used</td>
<td>24</td>
</tr>
<tr>
<td>Chilled Wheels, Test Specification</td>
<td>96</td>
</tr>
<tr>
<td>Chinese Eastern Six-Coupled Compound. (Illustration)</td>
<td>195</td>
</tr>
<tr>
<td>Chronicle, Extract from</td>
<td>12</td>
</tr>
<tr>
<td>Cia, Minera de Peñoles Rack and Adhesion Compound. (Illustration)</td>
<td>166, 198</td>
</tr>
<tr>
<td>Cincinnati, New Orleans and Texas Pacific Railway, Test</td>
<td>196</td>
</tr>
<tr>
<td>Citizens Railway of Baltimore, Separate Motor</td>
<td>71</td>
</tr>
<tr>
<td>Clark, David, Feed-Water Heater</td>
<td>53</td>
</tr>
<tr>
<td>Class Designations</td>
<td>107</td>
</tr>
<tr>
<td>Classification First Established</td>
<td>35</td>
</tr>
<tr>
<td>Cleaning Hole and Cap for Smoke Box</td>
<td>234</td>
</tr>
<tr>
<td>Cleaning Plugs</td>
<td>229</td>
</tr>
<tr>
<td>Cocks and Valves (with Illustration)</td>
<td>361</td>
</tr>
<tr>
<td>Code Numbers</td>
<td>213</td>
</tr>
<tr>
<td>Combination Rack and Adhesion Locomotive (with Illustration)</td>
<td>84, 85, 166, 187, 198</td>
</tr>
<tr>
<td>Combined Relief and Vacuum Valve for Compound Locomotive (with Illustration)</td>
<td>281</td>
</tr>
<tr>
<td>Combustion-Chamber Introduced</td>
<td>55</td>
</tr>
<tr>
<td>Comparative Difference between Stationary and Locomotive Boilers</td>
<td>162</td>
</tr>
<tr>
<td>Comparative Tests of Compound and Single Expansion Locomotives</td>
<td>189, 202</td>
</tr>
<tr>
<td>Composition Rings for Metallic Packing</td>
<td>230</td>
</tr>
<tr>
<td>Compound Cylinder and all parts (with Illustration)</td>
<td>230, 231, 269</td>
</tr>
<tr>
<td>Compound Cylinder and Valve (with Illustration)</td>
<td>151, 177</td>
</tr>
<tr>
<td>Compound Cylinder, Piston Valve and Bushing for (with Illustration)</td>
<td>271</td>
</tr>
<tr>
<td>Compound Locomotive. (Front View)</td>
<td>188</td>
</tr>
<tr>
<td>Compound Locomotives</td>
<td>145, 147</td>
</tr>
<tr>
<td>Compound Locomotives for Various Roads</td>
<td>179-189</td>
</tr>
<tr>
<td>Compound Wood and Iron Driving Wheels (with Illustration)</td>
<td>17, 18</td>
</tr>
<tr>
<td>Compressed Air Locomotive for Street-Cars</td>
<td>68</td>
</tr>
<tr>
<td>Condensing Steam Chest Oil Cup</td>
<td>234, 363</td>
</tr>
<tr>
<td>Consolidation Locomotive, Government of New Zealand</td>
<td>72</td>
</tr>
<tr>
<td>Consolidation Locomotives (with Illustration)</td>
<td>63, 86, 121, 180, 250</td>
</tr>
<tr>
<td>Consolidation Locomotive, Lehigh Valley Railroad</td>
<td>87</td>
</tr>
<tr>
<td>Contracts made in England and France</td>
<td>88</td>
</tr>
<tr>
<td>Converse, John H., Partnership</td>
<td>68</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Copper, Test Specification</td>
<td>94</td>
</tr>
<tr>
<td>Corcovado Railway, Rack-Rail Locomotive (with Illustration)</td>
<td>78</td>
</tr>
<tr>
<td>Corrugated Fire Boxes</td>
<td>72</td>
</tr>
<tr>
<td>Cost of Repairs, State Road Locomotives</td>
<td>23</td>
</tr>
<tr>
<td>Counterbalance Spring</td>
<td>232</td>
</tr>
<tr>
<td>Coupling Rods with Cylindrical Brassies</td>
<td>32</td>
</tr>
<tr>
<td>Crank or Wrist Pins</td>
<td>231, 285</td>
</tr>
<tr>
<td>Cross Flues placed in Fire Box</td>
<td>55</td>
</tr>
<tr>
<td>Crosshead, Compound Locomotive (with Illustration)</td>
<td>157, 295</td>
</tr>
<tr>
<td>Crosshead Filling Pieces</td>
<td>232</td>
</tr>
<tr>
<td>Crosshead for Valve Stem, Compound Locomotive (with Illustration)</td>
<td>297</td>
</tr>
<tr>
<td>Crosshead Gibs</td>
<td>232</td>
</tr>
<tr>
<td>Crosshead Pins</td>
<td>232</td>
</tr>
<tr>
<td>Crosshead, Single Expansion Locomotive (with Illustration)</td>
<td>232, 291, 293</td>
</tr>
<tr>
<td>Crossheads, Methods of Repairing</td>
<td>161</td>
</tr>
<tr>
<td>Cumberland Valley, Locomotive with Combustion-Chamber</td>
<td>55</td>
</tr>
<tr>
<td>Cut-off, Economical Point of</td>
<td>160</td>
</tr>
<tr>
<td>Cut-Off Valve</td>
<td>38</td>
</tr>
<tr>
<td>Cut-Off with Separate Valve and Independent Rock Shaft</td>
<td>51</td>
</tr>
<tr>
<td>Cuyahoga Cut-Off</td>
<td>52</td>
</tr>
<tr>
<td>Cylinder and Half-Saddle in One Piece</td>
<td>59</td>
</tr>
<tr>
<td>Cylinder Casing</td>
<td>230</td>
</tr>
<tr>
<td>Cylinder Casing Covers</td>
<td>229, 261</td>
</tr>
<tr>
<td>Cylinder Cock</td>
<td>234, 361</td>
</tr>
<tr>
<td>Cylinder Cock for Compound Locomotive (with Illustration)</td>
<td>231, 273</td>
</tr>
<tr>
<td>Cylinder Cock Work, for Single Expansion Locomotive (with Illustration)</td>
<td>275</td>
</tr>
<tr>
<td>Cylinder Cocks, Use of, in Compound Locomotives</td>
<td>158</td>
</tr>
<tr>
<td>Cylinder, Compound, and all parts (with Illustration)</td>
<td>230, 231</td>
</tr>
<tr>
<td>Cylinder, Compound (with Illustration)</td>
<td>230, 231, 265, 267</td>
</tr>
<tr>
<td>Cylinder Dimensions, Compound and Single Expansion. (Table)</td>
<td>145</td>
</tr>
<tr>
<td>Cylinder Gland</td>
<td>229</td>
</tr>
<tr>
<td>Cylinder Head, Back</td>
<td>229</td>
</tr>
<tr>
<td>Cylinder Head, Front</td>
<td>229</td>
</tr>
<tr>
<td>Cylinder Lubricator, Sight Feed (with Illustration)</td>
<td>234, 412, 414</td>
</tr>
<tr>
<td>Cylinder Oiler in Cab, B. L. W. Style</td>
<td>234, 363</td>
</tr>
<tr>
<td>Cylinder Relief Valve for Compound Locomotive</td>
<td>231, 279</td>
</tr>
<tr>
<td>Cylinder, Single Expansion (with Illustration)</td>
<td>229, 263</td>
</tr>
<tr>
<td>Cylinders, Compound, Description of (with Illustration)</td>
<td>149</td>
</tr>
<tr>
<td>Cylindrical Pedestals</td>
<td>23</td>
</tr>
<tr>
<td>Cylindrical Pedestals and Boxes Cast in Chills</td>
<td>29</td>
</tr>
<tr>
<td>Decapod Type for Dom Pedro Road</td>
<td>76</td>
</tr>
<tr>
<td>Decapod Type for New York, Lake Erie and Western Railroad</td>
<td>87</td>
</tr>
</tbody>
</table>
Decapod Type for St. Clair Tunnel (with Illustration) ........................................ 80
Deflecting Plate in Fire Box .............................................................................. 54
Delano Grate ......................................................................................................... 55
Denver and Rio Grande, Narrow-Gauge Locomotive ........................................ 65
Department Organized for Standard Gauges ....................................................... 59, 60
Description of Shops ........................................................................................... 5
Detachable Fire Box .............................................................................................. 24
Detroit Sight Feed Cylinder Lubricator (with Illustration) .............................. 414
Device for Forcing in Bushings (with Illustration) .............................................. 162
Device for Increasing Adhesion ........................................................................... 20
Diagram of Baldwin Compound Cylinders showing Course of Steam (with Illustration) .......................................................... 269
Diagram, Hauling Capacity of Locomotives ......................................................... 91
Diagram, Water Rate of Single Expansion and Compound Locomotives .............. 160
Diagram, Indicator Cards .................................................................................... 169
Diagram, Method of Combining Cards ................................................................ 171
Dimpfel Boiler Used .............................................................................................. 55
Dome-Boiler Abandoned ..................................................................................... 45
Dom Pedro II. Railway, Locomotives for .............................................................. 57
Dom Pedro Segundo Railway, "Mogul" Locomotive ............................................. 69
Double Cone ......................................................................................................... 229, 313
Double Eccentric Adopted ................................................................................... 25
"Double-End" Type Locomotive, Central Railroad of New Jersey ..................... 67
Draw Bar, Pilot ...................................................................................................... 233, 315
Drip Funnel (with Illustration) ............................................................................. 357
Drivers, Diameter of ............................................................................................ 22, 43
Driving Axle, Position of, Norris Locomotives .................................................... 19
Driving Axle (with Illustration) ............................................................................ 231, 285
Driving Box Brass ................................................................................................ 233
Driving Box Cellar ................................................................................................ 233
Driving Box (with Illustration) ............................................................................ 233, 347
Driving Boxes with Slot in Vertical Bearing ........................................................ 47
Driving Brake Cams .............................................................................................. 234
Driving Brake Heads ............................................................................................ 234
Driving Brake Shoes ............................................................................................ 234
Driving Brake, Steam (with Illustration) .............................................................. 343, 345
Driving Spring Links ............................................................................................ 232
Driving Springs .................................................................................................... 232
Driving Tires (with Illustration) .......................................................................... 231, 285
Driving Wheel Centre, Wrought Iron (with Illustration) .................................... 287
Driving Wheels Patented (with Illustration) ......................................................... 21, 22
Driving Wheels (with Illustration) ........................................................................ 231, 285

Early Patents ......................................................................................................... 18
Eastwick & Harrison Equalizing Beam ................................................................. 26
NARROW-GAUGE LOCOMOTIVES.

Eccentric Strap Oil Cup ........................................ 234
Eccentric Straps ............................................... 231
Eccentrics ....................................................... 231
Eclipse Injector (with Illustration) .......................... 399
Economical Point of Cut-off .................................. 160
Economy of Compound Locomotives ............................. 163
Eight-Wheel C Engines .......................................... 39
Eight-Wheel Connected (with Illustration) .................... 40
Eight-Wheel Locomotive "H. R. Campbell" ..................... 26
Eight-Wheel Tenders First Built ............................... 25
Electric Locomotive (with Illustration) ....................... 83
Ellet, Chares, Operation of Locomotives on Heavy Grades .... 48
Emergencies, Use of Starting Valve in ....................... 159
Enclosed Locomotives ......................................... 165, 182, 201
Engine Back Draw Bar ......................................... 234
Engine Front Draw Casting ...................................... 233
Engine Truck (with Illustration) ............................... 233, 319
Engine Truck Box Brass ......................................... 233
Engine Truck Box Cellar ........................................ 233
Engine Truck Box (with Illustration) .......................... 233, 347
Engine Truck Centre Pin ........................................ 233
Engine Truck Centre Pin Guide and Crosstie (with Illustration) 321
Engine Truck Flexible Beam .................................... 30, 31
Engine Truck Frame ............................................. 233, 319
Engine Truck Springs .......................................... 232
Engine Truck Swing Bolster ..................................... 233, 319
Engine Truck Wheel ............................................. 233, 319
Engine Truck Wheel Centre, Wrought Iron (with Illustration) 289
Engineer's Brake Valve (with Illustration) .................... 233, 367
Engines with Straight Boilers and Two Domes ................. 55
English Steel for Fire Boxes ................................... 58
Equalization of Eight-Wheel Locomotives .................... 26
Equalizing Beam Fulcrum ....................................... 232
Equalizing Beams .............................................. 232
Equalizing Work (with Illustration) .......................... 311
Erie and Kalamazoo Railroad, Four-Coupled Locomotive ...... 34
Estrada de Ferro Principe do Grão Pará Rack Locomotive (with Illustration) ... 78
Exhaust for the "Ironsides" ................................... 11
Exhaust in Compound Locomotives ............................. 164
Exhaust Nozzle and Thimbles .................................. 234, 337
Experiments in Combustion of Coal ........................... 54
Extract from Chronicle ........................................ 12
Extract from Letter of G. A. Nicolls .......................... 33
Extract from Locomotive Engineering ......................... 32
Extract from United States Gazette .......................... 12
Fan for Blowing Fire ........................................... 28
Fast Passenger Locomotive. (Illustration) .................. 43
Fast Passenger Locomotive for Bound Brook Line ........ 74
Fast Passenger Locomotive, Pennsylvania Railroad ....... 44
Fast Passenger Train Atlantic City Railroad ............... 86
F. C. de Merida à Valladolid “American” Type Compound
   (Illustration) .................................................. 191
Feed Cock (with Illustration) .................................. 233, 351, 359
Feed-Water Heater, Baltimore and Ohio Locomotive ....... 42
Feed-Water Heater, Patented by Baldwin & Clark ........ 53
Feed-Water Work (with Illustration) ......................... 353
Ferrules for Boiler Tubes ...................................... 229
Filling Pieces, Crosshead .................................... 232
Financial Embarrassments .................................... 24
Fire Box ......................................................... 229, 256
Fire Box Copper, Test Specification ......................... 94
Fire Box, Detachable .......................................... 24
Fire Box Material, Test Specification .............. 93, 94
Fire Boxes with Corrugated Sides ............................ 72
Fire-Brick Arch Used as a Deflector ....................... 54
Fire-Bricks, Supported on Side Plugs ....................... 54
Fire-Bricks, Supported on Water Tubes .................... 54
Fire-Bricks (with Illustration) .............................. 259
Fire Door ......................................................... 229, 257
Fire to be Carried for Compound Locomotives ............. 159
First Engine with Flexible Beam Truck ..................... 32
First Locomotive with Four Pairs Coupled Wheels .......... 40
First Locomotive with Half-Stroke Cut-off ................ 38
Firm Changed, Mr. Baird Retired ............................ 67
Five Thousandth Locomotive Completed ................. 74
Flexible Beam Truck (with Illustration) .............. 30, 31
Foot Boards (with Illustration) .............................. 325
Foot Plate .................................................... 234, 347
Foreign Business in 1890 .................................... 88
Forgings, Steel, Test Specification ........................ 95
Forward Equalizing Beam and Fulcrum ....................... 232, 311
Four Cylinder Locomotive .................................... 45
Frame Front Rail ............................................... 231
Frame Pedestal Cap ........................................... 231
Frames and Pedestals (with Illustration) ................. 231, 283
French & Baird Smoke Stack ................................ 37
French State Railways, Locomotives for .......... 88
French State Railways, “American” Type Compound. (Illus-
   tration) ................................................................ 168
Front and Door, Smoke Box ................................. 229, 261
Front Bumper (with Illustration) ............................ 315, 317
Grate Work, Rocking (with Illustration) ........................................ 329. 331
Grimes Patent Smoke Stack ...................................................... 37
Ground Joints for Steam Pipes .................................................. 20
Groups of Duplicate Parts with Code Words .................................. 229
Growth in Sixty-eight Years ...................................................... 88
Guaranteed Load, Consolidation Locomotive Lehigh Valley Rail-
road .......................................................................................... 87
Guide Bearer, Compound Locomotive (with Illustration) ................. 295
Guide Bearer, Single Expansion Locomotive (with Illustration) ......... 291. 293
Guide Oil Cup ............................................................................ 234. 363
Guides, Compound Locomotive (with Illustration) ......................... 295
Guides, Single Expansion Locomotive (with Illustration) ................. 232. 291. 293

Half-Crank Axle (with Illustration) ............................................. 14
Half-Stroke Cut-off .................................................................... 38
Hango-Hyvinge Railway of Finland, Locomotives for ...................... 67
Hardie, Robert, Compressed-Air Locomotive ................................. 74
Harrison, Joseph, Jr., Equalizing Beam ......................................... 26
Hawaiian Agricultural Co., Ltd., Four-Coupled Compound. (Illustration) ................................................................. 175
Headlight (with Illustration)......................................................... 234. 371
Headlight Shelf (with Illustration) ................................................ 355
Heater Valve .............................................................................. 233. 361
Heating Surface and Grate Area ................................................... 164
Heavy Grade on Virginia Central Railroad .................................... 47
Henszey, William P., Partnership .................................................. 62
High Speed Passenger Locomotive. (Illustration) ......................... 84
Hill & West, Dubuque, Motors ..................................................... 72
History ....................................................................................... 7
Horizontal Cylinders, Engine “Ocmulgee” ..................................... 58
Hudson River Railroad, Fast Passenger Locomotive ....................... 44

Illustrated Plates ........................................................................ 253
Importation of Steel Tires ............................................................ 57
Improvement in Iron Frames ....................................................... 20
Improvements in Wheels and Tubes for Locomotives ...................... 21
Increasing Weight of Locomotives .............................................. 36
Increasing Weight on Drivers, Device for ..................................... 44
Indicator Diagram, obtaining Water Rate from .............................. 167
Injector ....................................................................................... 233
Injector, Belfield (with Illustration) .............................................. 400
Injector Check (with Illustration) .................................................. 233. 359
Injector, Eclipse (with Illustration) ................................................ 399
Injector Feed Cock (with Illustration) .......................................... 233. 359
Injector, Korting (with Illustration) .............................................. 393
Injector, Little Giant 1889 (with Illustration) ............................... 402
NARROW-GAUGE LOCOMOTIVES.

Injector, Little Giant, “Locomotive” (with Illustration) .......... 401
Injector, Metropolitan Double Tube Locomotive (with Illustration) .................................................. 406
Injector, Monitor (with Illustration) .................................. 396
Injector, National and N. T. (with Illustration) ..................... 404
Injector, Sellers, 1876 (with Illustration) .......................... 387
Injector, Sellers, 1887 (with Illustration) .......................... 390
Injector Steam Valve (with Illustration) ......................... 233, 359
Injector Valves (with Illustration) .................................. 359
Instructions for Cabling .............................................. 207
Iron Flues First Used, Advantage of .............................. 36
Iron Tender Frame (with Illustration) .............................. 377
Iron, Test ..................................................................... 93, 95

Jacket Bands .................................................................. 229
Jacket, Boiler ............................................................... 229
Jaffa and Jerusalem, Locomotives for ................................ 80
James, W. T., Link-Motion .............................................. 49
Japan, First Locomotives for ......................................... 78
Jerome Metallic Packing for Piston Rods (with Illustration) ... 416
Jerome Metallic Packing for Valve Stems (with Illustration) ... 418
Johnson, Alba B., Partnership ........................................ 85
Journal Boxes (with Illustration) ..................................... 347

Kansas Pacific Railway, Tires Shrunk on .............................. 67
Keys, Rod ..................................................................... 232, 395
Korting Injector (with Illustration) ................................. 393
Koursk Charkof Azof Railway, Locomotives for .................... 73

Lagging, Boiler ................................................................ 229
Legislature decides to adopt Steam Power .......................... 16
Lehigh Valley Consolidation Locomotives .......................... 62, 69, 87
Link-Motion Applied, Central Railroad of Georgia ............. 53
Link-Motion First Applied .............................................. 49
Links .......................................................................... 232, 299
Little Giant Injector, 1889 (with Illustration) .................... 402
Little Giant Injector, “Locomotive” (with Illustration) ........ 401
Location ....................................................................... 5
Locomotive “Alamosa,” Performance of ............................ 66
Locomotive, “American” Type. (Illustration) ................. 111, 113, 147, 168, 185, 191, 192, 244
Locomotive, “Atlantic” Type. (Illustration) ...................... 83, 86, 87, 115, 197, 199, 245
Locomotive “Belle,” First Variable Cut-off ........................ 52
Locomotive “Best Friend,” Charleston and Hamburg Railroad.. 14
Locomotive “Black Hawk” .............................................. 21
Locomotive “Champlain” Philadelphia and Reading Railroad, Half-Stroke Cut-off .................................................. 39
Locomotive, “Columbia” Type. (Illustration) .......................... 245
Locomotive, “Consolidation” Type (with Illustration). 63, 86, 121, 180, 250
Locomotive Constructed in Sixteen Working Days ............. 68
Locomotive, “Decapod” Type. (Illustration) ......................... 80, 189, 251
Locomotive Details ............................................................ 205
Locomotive, Double-Ender. (Illustration) ............................. 67, 77, 131, 135, 137, 148, 158, 182, 193
Locomotive “E. A. Douglas,” First “Mogul” (with Illustration) 63
Locomotive, Eight Coupled, with Flexible-Beam Truck ......... 49
Locomotive, Enclosed Switching. (Illustration) .................... 165, 182, 201
Locomotive Engineering, Extract from .................................. 32
Locomotive, First Compound, in 1889 ................................. 79
Locomotive for Austria in 1840 ............................................. 28
Locomotive for Denver and Rio Grande, Description of ....... 65
Locomotive for Government of Victoria ............................... 73
Locomotive for Rack-Rail (with Illustration) ......................... 78, 79, 80, 81, 84, 85, 166, 170, 178, 186, 198, 239
Locomotive for Single Rail .................................................... 66
Locomotive for State Road .................................................... 16
Locomotive, Four Coupled, with Flexible Beam Truck .......... 33
Locomotive “Governor Paine” (with Illustration) ................... 43
Locomotive, High Speed, “Atlantic” Type (with Illustration) 83
Locomotive “John Brough,” Rack-Rail ................................. 42
Locomotive “Lancaster” Pennsylvania Railroad .................... 16
Locomotive “Media,” Fire-Bricks supported on Water Tubes .... 54
Locomotive, Metre Gauge, for Brazil ..................................... 66
Locomotive “M. G. Bright” (with Illustration) ...................... 41
Locomotive “Miller,” with Drivers back of Fire Box and Four-Wheel Leading Truck .................................................. 141
Locomotive, “Mogul” Type. (Illustration) 63, 117, 150, 176, 181, 183, 190, 195, 196, 247
Locomotive “New England,” with Iron Tubes, Test ................ 39
Locomotive, “Old Ironsides” ................................................. 10
Locomotive “Ontario,” with Copper Tubes, Test ................... 36
Locomotive, Rack and Adhesion. (Illustration) 84, 85, 166, 186, 198
Locomotive, Shortest Time of Construction .......................... 79
Locomotive, Single Pair of Drivers, Express (with Illustration) .......................................................... 74, 84, 144
Locomotive, Six Coupled, with Flexible-Beam Truck ............ 30, 81
Locomotive “Susquehanna” .................................................... 44
Locomotive, “Ten-Wheel” Type. (Illustration) 85, 119, 149, 152, 172, 176, 181, 184, 194, 248
Locomotive to Operate by Compressed Air ............................ 68, 164, 174
Locomotive, Twenty inches Gauge ....................................... 67
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotive Types Illustrated</td>
<td>238, 252</td>
</tr>
<tr>
<td>Locomotive &quot;West Chester,&quot; Weight, etc.</td>
<td>23</td>
</tr>
<tr>
<td>Locomotive, West Point Foundry</td>
<td>8</td>
</tr>
<tr>
<td>Locomotive with Four Drivers and Four Truck Wheels</td>
<td>39</td>
</tr>
<tr>
<td>Locomotive with Outside Frames (with Illustration)</td>
<td>77</td>
</tr>
<tr>
<td>Locomotives at the Centennial Exhibition</td>
<td>69</td>
</tr>
<tr>
<td>Locomotives Built during 1834</td>
<td>19</td>
</tr>
<tr>
<td>Locomotives &quot;Clinton,&quot; &quot;Athens,&quot; and &quot;Sparta&quot;</td>
<td>47</td>
</tr>
<tr>
<td>Locomotives Exhibited at the Columbian Exposition</td>
<td>82</td>
</tr>
<tr>
<td>Locomotives for Africa</td>
<td>81</td>
</tr>
<tr>
<td>Locomotives for Cantagallo Railway</td>
<td>75</td>
</tr>
<tr>
<td>Locomotives for Grand Trunk in 1873</td>
<td>68</td>
</tr>
<tr>
<td>Locomotives for Norwegian State Railway (with Illustration)</td>
<td>73, 176</td>
</tr>
<tr>
<td>Locomotives, Imported</td>
<td>8</td>
</tr>
<tr>
<td>Locomotives &quot;Mifflin,&quot; &quot;Blair,&quot; and &quot;Indiana&quot;</td>
<td>44</td>
</tr>
<tr>
<td>Locomotives Ordered in 1882</td>
<td>75</td>
</tr>
<tr>
<td>Locomotives to Burn Cumberland Coal</td>
<td>42</td>
</tr>
<tr>
<td>Locomotives to Burn Russian Anthracite Coal</td>
<td>67</td>
</tr>
<tr>
<td>Locomotives, Train of. (()Illustration)</td>
<td>146</td>
</tr>
<tr>
<td>Locomotives Turned Out during 1861</td>
<td>56</td>
</tr>
<tr>
<td>Locomotives with Upright Boilers and Horizontal Cylinders</td>
<td>29</td>
</tr>
<tr>
<td>Long Island Railroad Suburban Compound. (Illustration)</td>
<td>200</td>
</tr>
<tr>
<td>Long Island Railroad, Test</td>
<td>197</td>
</tr>
<tr>
<td>Longstreth, Edward, Partnership</td>
<td>62</td>
</tr>
<tr>
<td>Longstreth, Edward, Retires</td>
<td>77</td>
</tr>
<tr>
<td>Louisville and Nashville Railroad, Six Coupled with Bissell Truck</td>
<td>57</td>
</tr>
<tr>
<td>Lubricator, Sight Feed</td>
<td>234, 411, 413</td>
</tr>
<tr>
<td>Madison and Indianapolis Railroad, Rack Locomotive (with Illustration)</td>
<td>41</td>
</tr>
<tr>
<td>Manitou and Pike's Peak Railway Rack Compound. (Illustration)</td>
<td>80, 178</td>
</tr>
<tr>
<td>Manufacture of Shot and Shell Contemplated in 1861</td>
<td>56</td>
</tr>
<tr>
<td>Mason, David, Partnership</td>
<td>7</td>
</tr>
<tr>
<td>Material, Physical Tests of</td>
<td>93</td>
</tr>
<tr>
<td>Meier Iron Company, Locomotive for</td>
<td>68</td>
</tr>
<tr>
<td>Metallic Packing</td>
<td>230</td>
</tr>
<tr>
<td>Metallic Packing, 1840</td>
<td>29</td>
</tr>
<tr>
<td>Metallic Packing, Composition Rings for</td>
<td>230</td>
</tr>
<tr>
<td>Metallic Packing for Piston Rods (with Illustration)</td>
<td>416</td>
</tr>
<tr>
<td>Metallic Packing for Valve Stems (with Illustration)</td>
<td>418</td>
</tr>
<tr>
<td>Method of Combining Indicator Diagram</td>
<td>171</td>
</tr>
<tr>
<td>Method of Determining Water Rate per Horse-Power</td>
<td>167</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Metropolitan Double Tube Locomotive Injector (with Illustration)</td>
<td>406</td>
</tr>
<tr>
<td>Mexican National Construction Company, Order from</td>
<td>75</td>
</tr>
<tr>
<td>Mexican National Railroad, Ten-Wheel Compound. (Illustration)</td>
<td>184</td>
</tr>
<tr>
<td>Midland Railway of England, Locomotives for</td>
<td>88</td>
</tr>
<tr>
<td>Mie Kie Mines Locomotives, First for Japan</td>
<td>78</td>
</tr>
<tr>
<td>Mileage of Four-Wheel Truck</td>
<td>64</td>
</tr>
<tr>
<td>Military Railroads, Locomotives for</td>
<td>57</td>
</tr>
<tr>
<td>&quot;Miller, E. L.,&quot; Locomotive for Charleston and Hamburg Railroad</td>
<td>15</td>
</tr>
<tr>
<td>Mine Hill Railroad, Locomotive with Peculiar Crown Sheet</td>
<td>56</td>
</tr>
<tr>
<td>Mine Locomotives, Inside and Outside Connected</td>
<td>66</td>
</tr>
<tr>
<td>Miniature Locomotive</td>
<td>9</td>
</tr>
<tr>
<td>Mishaps on First Trip of &quot;Ironsides&quot;</td>
<td>13</td>
</tr>
<tr>
<td>Missouri, Kansas and Texas Ten-Wheel Compound. (Illustration)</td>
<td>194</td>
</tr>
<tr>
<td>Mitchell, Alexander, &quot;Consolidation&quot; Type (with Illustration)</td>
<td>62, 63</td>
</tr>
<tr>
<td>Mogul Locomotives ...</td>
<td>63, 73, 116, 150, 176, 181, 183, 190, 195, 196, 247</td>
</tr>
<tr>
<td>Monitor Injector (with Illustration)</td>
<td>396</td>
</tr>
<tr>
<td>Morrow, William H., Partnership</td>
<td>77</td>
</tr>
<tr>
<td>Morrow, William H., Death of</td>
<td>78</td>
</tr>
<tr>
<td>Mountain Top Track</td>
<td>49</td>
</tr>
<tr>
<td>Narrow-Gauge Consolidation, 1873</td>
<td>65</td>
</tr>
<tr>
<td>Narrow-Gauge Locomotive, Averill Coal and Oil Company</td>
<td>65</td>
</tr>
<tr>
<td>Nathan Sight Feed Cylinder Lubricator (with Illustration)</td>
<td>412</td>
</tr>
<tr>
<td>National and N. T. Injector (with Illustration)</td>
<td>494</td>
</tr>
<tr>
<td>New Form of Boiler, Denver and Rio Grande Railroad</td>
<td>78</td>
</tr>
<tr>
<td>New Shop Completed</td>
<td>21</td>
</tr>
<tr>
<td>New Mode of Constructing Wheels</td>
<td>18</td>
</tr>
<tr>
<td>New Mode of Forming Joints and Other Parts of Supply Pumps</td>
<td>18</td>
</tr>
<tr>
<td>New Mode of Forming Joints in Steam Boilers</td>
<td>18</td>
</tr>
<tr>
<td>New South Wales and Queensland, First Locomotives for</td>
<td>72</td>
</tr>
<tr>
<td>New South Wales Government, Tramway Motors</td>
<td>74</td>
</tr>
<tr>
<td>New York and Erie Locomotives</td>
<td>44</td>
</tr>
<tr>
<td>New York, Chicago and St. Louis, Comparison</td>
<td>201</td>
</tr>
<tr>
<td>New York, Lake Erie and Western, &quot;Decapod&quot;</td>
<td>81</td>
</tr>
<tr>
<td>Nicolls, G. A., Extract from Letter</td>
<td>33</td>
</tr>
<tr>
<td>Norfolk and Western, Test</td>
<td>194</td>
</tr>
<tr>
<td>Norris, Septemus, Ten-Wheeled Locomotive Patent</td>
<td>45</td>
</tr>
<tr>
<td>Norris, William</td>
<td>19</td>
</tr>
<tr>
<td>Northern Pacific Mogul Compound. (Illustration)</td>
<td>195</td>
</tr>
<tr>
<td>Northern Pacific Railroad, Order</td>
<td>67</td>
</tr>
<tr>
<td>Northern Pacific, Test</td>
<td>189, 201</td>
</tr>
<tr>
<td>Norwegian State Railway, Mogul Compound. (Illustration)</td>
<td>176</td>
</tr>
<tr>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Norwegian State Railway Ten-Wheelers</td>
<td>73</td>
</tr>
<tr>
<td>Number of Hands Employed in 1837</td>
<td>24</td>
</tr>
<tr>
<td>Number of Locomotives Constructed from 1835 to 1840</td>
<td>22</td>
</tr>
<tr>
<td>Number of Locomotives Constructed from 1851 to 1854</td>
<td>45</td>
</tr>
<tr>
<td>Objections to Eight-Wheeled Locomotive</td>
<td>27</td>
</tr>
<tr>
<td>&quot;Ocmulgee,&quot; First Locomotive with Horizontal Cylinders</td>
<td>58</td>
</tr>
<tr>
<td>Oeste de Minas, Brazil, Ten-Wheel Compound. (Illustration)</td>
<td>185</td>
</tr>
<tr>
<td>Ohio and Mississippi, Change in Gauge</td>
<td>67</td>
</tr>
<tr>
<td>Oil Burning Apparatus (with Illustration)</td>
<td>385</td>
</tr>
<tr>
<td>Oil Cup, Eccentric Strap</td>
<td>234</td>
</tr>
<tr>
<td>Oil Cup, Guide (with Illustration)</td>
<td>234, 363</td>
</tr>
<tr>
<td>Oil Cup, Rock Shaft (with Illustration)</td>
<td>234, 363</td>
</tr>
<tr>
<td>Oil Cup, Rod (with Illustration)</td>
<td>234, 363</td>
</tr>
<tr>
<td>Oil Cup, Steam Chest (with Illustration)</td>
<td>234, 363</td>
</tr>
<tr>
<td>Oil Cups (with Illustration)</td>
<td>363</td>
</tr>
<tr>
<td>&quot;Old Ironsides.&quot; (Illustration)</td>
<td>10</td>
</tr>
<tr>
<td>&quot;Old Ironsides,&quot; Work Begun</td>
<td>9</td>
</tr>
<tr>
<td>Operation of the Vaclain Compound</td>
<td>158</td>
</tr>
<tr>
<td>Orders for Locomotives in 1882</td>
<td>75</td>
</tr>
<tr>
<td>Orel Griazi Railway, Russia, Locomotives for</td>
<td>73</td>
</tr>
<tr>
<td>Organization, Present</td>
<td>89</td>
</tr>
<tr>
<td>Outside Cylinders, Mr. Baldwin the First American Builder</td>
<td>58</td>
</tr>
<tr>
<td>Packing Piston (with Illustration)</td>
<td>230, 307</td>
</tr>
<tr>
<td>Parry, Charles T., Partnership</td>
<td>62</td>
</tr>
<tr>
<td>Parry, Charles T., Death of</td>
<td>78</td>
</tr>
<tr>
<td>Partnership Formed with Asa Whitney</td>
<td>35</td>
</tr>
<tr>
<td>Paulista Railway, Brazil, &quot;American&quot; Type Compound. (Illustration)</td>
<td>185</td>
</tr>
<tr>
<td>Peale, Franklin. Philadelphia Museum</td>
<td>9</td>
</tr>
<tr>
<td>Pedestal Cap</td>
<td>231</td>
</tr>
<tr>
<td>Pedestal Gib</td>
<td>231</td>
</tr>
<tr>
<td>Pedestal, Tender</td>
<td>235</td>
</tr>
<tr>
<td>Pedestal Wedge</td>
<td>231</td>
</tr>
<tr>
<td>Pedestal Wedge Bolt</td>
<td>231</td>
</tr>
<tr>
<td>Pedestals, Cylindrical</td>
<td>23</td>
</tr>
<tr>
<td>Pennsylvania Railroad, Fast Passenger Locomotive</td>
<td>44</td>
</tr>
<tr>
<td>Pennsylvania Railroad, First Locomotive with Steel Fire Box</td>
<td>58</td>
</tr>
<tr>
<td>Pennsylvania Railroad, First to Use Steel Boiler</td>
<td>64</td>
</tr>
<tr>
<td>Pennsylvania Railroad, Four-Wheel Swing Bolster Truck</td>
<td>64</td>
</tr>
<tr>
<td>Pennsylvania Railroad, Locomotive with Fire-Brick Arch</td>
<td>54</td>
</tr>
<tr>
<td>Pennsylvania Railroad, Locomotive with Steel Flues</td>
<td>64</td>
</tr>
<tr>
<td>Pennsylvania Railroad, Ten-Wheeled Locomotive</td>
<td>46</td>
</tr>
<tr>
<td>Pennsylvania State Railroad, Locomotive for</td>
<td>16</td>
</tr>
<tr>
<td>Performance of &quot;Atlantic&quot; Type Locomotive, Atlantic City Railroad</td>
<td>86, 203</td>
</tr>
</tbody>
</table>
Performance of Locomotives, Centennial Narrow-Gauge .......... 69
Performance of Locomotives, Cantagallo Railway .......... 75
Performance of Street-Car Motors ........................ 72
Performance on Grades by Wm. J. Lewis .................... 26
Philadelphia and Columbia Railroad, Locomotive "Brandywine" 21
Philadelphia and Reading, "Atlantic" Type Compound. (Illustration) .................................................. 86, 197
Philadelphia and Reading Coal and Iron Company Compound Compressed Air Locomotives. (Illustrations) ............. 164, 174
Philadelphia and Reading, First Locomotive with Iron Tubes.. 36
Philadelphia and Reading Flexible-Beam Truck ................. 32
Philadelphia and Reading, High-Speed Locomotive (with Illustration) ..................................................... 83, 84
Philadelphia and Reading Railroad, Test ....................... 198
Philadelphia and Reading, Single Pair Drivers Locomotive. (Illustration) ................................................ 84, 144
Philadelphia and Trenton Railroad, Locomotive "Black Hawk" 21
Philadelphia, Wilmington and Baltimore, Dimpfel Boiler ....... 55
Phosphor Bronze, Test Specification .......................... 97
Physical Tests of Materials .................................... 93
Pike's Peak Rack Locomotive (with Illustration) .............. 79, 80, 178
Pilot Bull Nose ................................................. 233
Pilot Draw Bar .................................................. 233
Pilot (with Illustration) ........................................ 233, 315, 317
Piston for Compound Locomotive (with Illustration) ......... 155
Piston Packing .................................................. 230
Piston Packing, Compound Locomotive ......................... 163
Piston Rods ..................................................... 230, 307
Piston Valve and Bushing for Compound Cylinder (with Illustration) ..................................................... 153, 231, 271
Piston (with Illustration) ....................................... 230, 307
Plain Grate for Soft Coal (with Illustration) ................... 335
Plain Grate for Wood (with Illustration) ....................... 333
Plan of Works ................................................. 5
Plantation Locomotive, Ramal Dumont, Brazil .................. 187
Plug, Cleaning ................................................. 229
Plug, Fusible .................................................. 229
Plymouth Cordage Company, Compressed Air Locomotive ...... 68
Pneumatic Tramway Engine Company, Locomotive ............... 74
Position of Eccentrics (with Illustration) ..................... 154
Preface to Catalogue ......................................... 90
Present Organization .......................................... 89
Price of Locomotive "Ironsides" ................................ 11
Production for 1892 and 1893 ................................ 82
Production from 1855 to 1860 ................................ 54-55
Production from 1866 to 1871 ................................ 62
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production from 1871 to 1873</td>
<td>67</td>
</tr>
<tr>
<td>Production from 1874 to 1875</td>
<td>68</td>
</tr>
<tr>
<td>Production from 1872 to 1899</td>
<td>73, 74</td>
</tr>
<tr>
<td>Pump and Stirrup (with Illustration)</td>
<td>19</td>
</tr>
<tr>
<td>Pump Check (with Illustration)</td>
<td>232, 351</td>
</tr>
<tr>
<td>Pump Feed Cock</td>
<td>232</td>
</tr>
<tr>
<td>Pump Plunger</td>
<td>232</td>
</tr>
<tr>
<td>Pump (with Illustration)</td>
<td>232, 349</td>
</tr>
<tr>
<td>Rack and Adhesion Locomotive (with Illustration)</td>
<td>84, 85, 166, 186, 198</td>
</tr>
<tr>
<td>Rack Locomotive, Compound. (Illustration)</td>
<td>80, 81, 170, 178, 239</td>
</tr>
<tr>
<td>Rack Locomotive, Principe do Grão Pará</td>
<td>77</td>
</tr>
<tr>
<td>Rack-Rail Locomotive, Abt System. (Illustration)</td>
<td>80, 84, 85</td>
</tr>
<tr>
<td>Rack-Rail Locomotive (with Illustration)</td>
<td>78, 85</td>
</tr>
<tr>
<td>Radial Stay, Wagon-Top Boiler</td>
<td>78</td>
</tr>
<tr>
<td>Radius Bar Crosstie and Clamp (with Illustration)</td>
<td>321</td>
</tr>
<tr>
<td>Radley &amp; Hunter Smoke Stack</td>
<td>38</td>
</tr>
<tr>
<td>Ramal Dumont, Brazil, Plantation Compound. (Illustration)</td>
<td>187</td>
</tr>
<tr>
<td>Ramal Ferreo Campeneiro, Brazil, Double Ender Compound. (Illustration)</td>
<td>193</td>
</tr>
<tr>
<td>Rate of Combustion, Compound Locomotive</td>
<td>165</td>
</tr>
<tr>
<td>Reach Rod</td>
<td>234</td>
</tr>
<tr>
<td>Reasons for Compounding</td>
<td>147</td>
</tr>
<tr>
<td>Record of Locomotives Built</td>
<td>88</td>
</tr>
<tr>
<td>Relief and Vacuum Valve for Compound Locomotive (with Illustration)</td>
<td>157, 231, 279, 281</td>
</tr>
<tr>
<td>Relief Valve, Steam Chest</td>
<td>230</td>
</tr>
<tr>
<td>Renewal of Piston Rings</td>
<td>161</td>
</tr>
<tr>
<td>Reorganization of Business</td>
<td>62</td>
</tr>
<tr>
<td>Repairs on Compound Locomotives</td>
<td>161</td>
</tr>
<tr>
<td>Result of Trial, Locomotive “Ironsides”</td>
<td>12</td>
</tr>
<tr>
<td>Reverse Lever Rod, or Reach Rod</td>
<td>234</td>
</tr>
<tr>
<td>Reverse Lever, Use of, in Compound Locomotives</td>
<td>158</td>
</tr>
<tr>
<td>Reverse Lever (with Illustration)</td>
<td>234, 341</td>
</tr>
<tr>
<td>Reverse Shaft and Bearings (with Illustration)</td>
<td>232, 299</td>
</tr>
<tr>
<td>Riggenbach System Rack Locomotive (with Illustration)</td>
<td>78</td>
</tr>
<tr>
<td>Rock Fish Gap</td>
<td>47</td>
</tr>
<tr>
<td>Rocking Grates</td>
<td>233</td>
</tr>
<tr>
<td>Rocking Grate First Introduced</td>
<td>42</td>
</tr>
<tr>
<td>Rocking Grate Work (with Illustration)</td>
<td>329, 331</td>
</tr>
<tr>
<td>Rockshaft</td>
<td>232, 299</td>
</tr>
<tr>
<td>Rockshaft Boxes</td>
<td>232, 299</td>
</tr>
<tr>
<td>Rockshaft Oil Cup</td>
<td>234</td>
</tr>
<tr>
<td>Rockshaft Rod and Hanger for Compound Locomotive (with Illustration)</td>
<td>301</td>
</tr>
<tr>
<td>Rod Brasses (with Illustration)</td>
<td>232, 304</td>
</tr>
<tr>
<td>Topic</td>
<td>Page(s)</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Rod Keys</td>
<td>232</td>
</tr>
<tr>
<td>Rod Oil Cup</td>
<td>234, 363</td>
</tr>
<tr>
<td>Rod Straps (with Illustration)</td>
<td>232, 304</td>
</tr>
<tr>
<td>Rods (with Illustration)</td>
<td>232, 304</td>
</tr>
<tr>
<td>Rogers, Thomas, Link Motion Adopted</td>
<td>50</td>
</tr>
<tr>
<td>Royal Railroad Company of Wurtemburg</td>
<td>38</td>
</tr>
<tr>
<td>Rumford Falls and Rangely Lakes Mogul Compound. (Illustration)</td>
<td>190</td>
</tr>
<tr>
<td>Russian Locomotives, Compound</td>
<td>84</td>
</tr>
<tr>
<td>Russian Railways, Mogul Locomotives</td>
<td>73</td>
</tr>
<tr>
<td>Safety Valves</td>
<td>229, 257</td>
</tr>
<tr>
<td>Salinas Railway Enclosed Motor, Compound. (Illustration)</td>
<td>201</td>
</tr>
<tr>
<td>Sample Locomotives for Russia</td>
<td>68</td>
</tr>
<tr>
<td>Sand Box, First Used</td>
<td>41</td>
</tr>
<tr>
<td>Sand Box (with Illustration)</td>
<td>232, 323</td>
</tr>
<tr>
<td>San Jose and Alum Rock Railway Enclosed Compound. (Illustration)</td>
<td>182</td>
</tr>
<tr>
<td>Santa Domingo Railway, Rack and Adhesion, Compound. (Illustration)</td>
<td>186</td>
</tr>
<tr>
<td>&quot;Socavon&quot; Combination Rack and Adhesion, Compound. (Illustration)</td>
<td>166</td>
</tr>
<tr>
<td>S. Ellero-Saltino (Vallombrosa), Rack Locomotive (with Illustration)</td>
<td>81, 170</td>
</tr>
<tr>
<td>Sellers Injector, 1876 (with Illustration)</td>
<td>387</td>
</tr>
<tr>
<td>Sellers Injector, 1887 (with Illustration)</td>
<td>390</td>
</tr>
<tr>
<td>Sentences for Cabling</td>
<td>222</td>
</tr>
<tr>
<td>Separate Motor for Street Service</td>
<td>71</td>
</tr>
<tr>
<td>Series 900 (with Illustration)</td>
<td>122</td>
</tr>
<tr>
<td>Series 901</td>
<td>128</td>
</tr>
<tr>
<td>Series 903</td>
<td>124</td>
</tr>
<tr>
<td>Series 904</td>
<td>126</td>
</tr>
<tr>
<td>Series 905</td>
<td>130</td>
</tr>
<tr>
<td>Series 907</td>
<td>114</td>
</tr>
<tr>
<td>Series 908</td>
<td>110</td>
</tr>
<tr>
<td>Series 909</td>
<td>138</td>
</tr>
<tr>
<td>Series 910</td>
<td>140</td>
</tr>
<tr>
<td>Series 911</td>
<td>116</td>
</tr>
<tr>
<td>Series 912</td>
<td>134</td>
</tr>
<tr>
<td>Series 913</td>
<td>118</td>
</tr>
<tr>
<td>Series 914</td>
<td>120</td>
</tr>
<tr>
<td>Series 915</td>
<td>136</td>
</tr>
<tr>
<td>Series 916</td>
<td>132</td>
</tr>
<tr>
<td>Series 917</td>
<td>112</td>
</tr>
<tr>
<td>Shops, Location of</td>
<td>17</td>
</tr>
<tr>
<td>Shops Partially Destroyed</td>
<td>17</td>
</tr>
</tbody>
</table>
NARROW-GAUGE LOCOMOTIVES.

Sight Feed Cylinder Lubricator (with Illustration) ........... 234, 412, 414
Signal Light Bracket (with Illustration) ....................... 355
Single Expansion Cylinder, Steam Chest, and Attachments (with Illustration) .................................................. 263
Single Rail Locomotive .............................................. 66
Six-Wheels Connected Locomotive (with Illustration) ........... 30
Size of Locomotive Increased ....................................... 36
Sizes and Weights of Locomotives in 1840 ......................... 22
Sketch of Mr. Baldwin ............................................. 61
Slide or Steam Chest Valves ........................................ 230, 263
Smith, A. F., Combustion Chamber ................................ 55
Smoke Box Cleaning Holes and Caps ................................ 234
Smoke Box Fittings (with Illustration) .......................... 337
Smoke Box Front and Door (with Illustration) ................... 229, 261
Smoke Box Netting .................................................. 234, 337
Smoke Stack Base (with Illustration) ............................. 232, 261
Smoke Stack Cone ................................................... 232
Smoke Stack, French & Baird ....................................... 37
Smoke Stack Netting ................................................ 232
Smoke Stack, Radley & Hunter ..................................... 38
Smoke Stack (with Illustration) ................................... 232, 313
Soft Coal Burning Grate (with Illustration) ...................... 335
South Carolina Railroad, “American” Type Locomotive ........... 39
Southeastern Railroad of Russia, Ten-Wheel Compound. (Illustration) ................................. 152
Southwestern Railway of Georgia, Horizontal Cylinders .......... 58
Spark Ejector .......................................................... 234
Spark Ejector Valve .................................................. 234
Special Conditions of Service ..................................... 142
Specification Form .................................................. 98
Specifications, General ............................................. 93
Speed of Locomotive “Ironsides” ................................. 12
Speed of Passenger Locomotive, Vermont Central ................. 44
Speed of Pennsylvania Locomotives ................................ 44
Spiral Springs for Engine Truck .................................... 29
Spiral Springs in Pedestal Boxes ................................... 29
Sprague, Duncan & Hutchison, Electric Locomotive (with Illustration) .................................................. 83
Spring Steel, Test Specification ................................... 96
Springs (with Illustration) ......................................... 232, 311
Standard Gauges and Templets ..................................... 59
Standard Gauges First Proposed ................................... 25
Starting Device in Emergencies .................................... 159
Starting Valve for Compound Cylinders (with Illustration) ..... 231, 273
Starting Valve for Compound Locomotives (with Illustration) 156
Starting Valve, Position of. (Illustration) ....................... 157
State Transcaucasian Railway, Compound Locomotives (Illustration) .................................................. 173, 189, 202
State Transcaucasian Railway, "Decapod" Type, Compound. (Illustration) .............................................. 189
Stationary Engine (with Illustration) .......................... 8
Stay Bolts, Test Specification .................................. 94
St. Clair Tunnel, Decapod (with Illustration) .............. 80
Steam Brake Piston (with Illustration) ....................... 367
Steam Brake Stop Valve ........................................ 233
Steam Brake Valve for Engineer ............................... 233
Steam Brake Work (with Illustration) ......................... 343, 345
Steam Chest Caps or Lids ....................................... 230
Steam Chest Casing ............................................. 230
Steam Chest Casing Covers .................................... 230
Steam Chest, Description of ................................... 153
Steam Chest for Cut-off ........................................ 38
Steam Chest Glands ............................................ 230
Steam Chest Oil Cup, Condensing ............................... 234, 353
Steam Chest or Slide Valves ................................... 230, 263
Steam Chest Relief Valves ..................................... 230
Steam Chests .................................................... 230, 263
Steam Chest Valve Yokes ....................................... 230, 263
Steam Consumption, Compound Locomotive .................. 164
Steam Gauge ................................................... 233
Steam Gauge Lamp Globe ....................................... 233
Steam Gauge Lamp (with Illustration) ......................... 233, 359
Steam Gauge Lamp Stand ....................................... 233
Steam Gauge Stand (with Illustration) ....................... 233, 357
Steam Inspection Car (with Illustration) ..................... 75
Steam Motor for Street-Cars. (Illustration) ................. 72
Steam Pipes .................................................... 229, 256
Steam Street-Car .............................................. 70
Steam Street-Car Reconstructed (with Illustration) ........ 71
Steam Valve, Injector ......................................... 233, 359
Steel Axles, First Used ....................................... 45
Steel Boilers, First Introduced ................................ 64
Steel Cylinder Head Cover (with Illustration) .............. 261
Steel Fire Boxes, First Introduced ........................... 58
Steel Flues, First Introduced .................................. 64
Steel in Locomotive Construction ............................. 57
Steel Smoke Box Front (with Illustration) .................... 261
Steel Stack Base (with Illustration) ......................... 261
Steel, Test Specification ...................................... 93, 95
Steel Tires, First Used ........................................ 57
Steel Tires, Test Specification ................................ 97
Steel Tires Made with Shoulder (with Illustration) ....... 58
NARROW-GAUGE LOCOMOTIVES.

Stephenson Link Motion ........................................ 38
Stephenson, Robert, & Co........................................ 14
Stop Valve for Steam Brake .................................... 233
Straight and Wagon-Top Boilers ............................... 64
Straps, Rod (with Illustration) ............................... 232, 304
Stroud, William C., Partnership ............................. 77
Stroud, William C., Death of ................................. 81
Suburban Locomotive Long Island Railroad.................. 200
Suggestions for Running Vauclain Four-Cylinder Compound.. 177
Swing Bolster, Engine Truck .................................. 233, 319
Swing Bolster Truck, Four-Wheel Plan ....................... 64
Sykes, L. A., Opinion of Baldwin Engine ................... 23
Table of Equivalent Cylinder Dimensions, Single Expansion
and Compound .................................................. 145

Tank Cock ......................................................... 234
Tank Funnel and Lid ............................................ 234
Tank Plates, Test Specification ............................... 95
Tank, Water (with Illustration) ............................... 234, 373
Telegraphic Code, Groups of Parts ......................... 229
Telegraphic Code Numbers ..................................... 213
Telegraphic Code Sentences ................................... 223
Telegraphic Code, Specification ............................. 419
Tender .......................................................... 234
Tender Back Draw Casting ..................................... 234
Tender Box Brasses ............................................ 233
Tender Box Wedges ............................................ 233
Tender Box (with Illustration) ............................... 233, 347
Tender Brake Heads ............................................ 235
Tender Brake Shoes ............................................ 235
Tender Brake Work (with Illustration) ....................... 383
Tender Chafing Casting ....................................... 234
Tender Frame Centre Pins ..................................... 235
Tender Frame, Iron (with Illustration) ....................... 377
Tender Frame, Wood (with Illustration) ..................... 375
Tender Front Draw Casting ................................... 234
Tender Pedestals ................................................. 235
Tender Springs ................................................. 232
Tender Truck Centre Plates ................................... 235
Tender Truck (with Illustration) ............................. 235, 379, 381
Tender Truck, Wood (with Illustration) ..................... 379
Tender Truck, Wrought Iron (with Illustration) .......... 381
Tender Wedge ................................................... 234
Tender Wedge Box .............................................. 234
Tender Wheel Centre, Wrought Iron (with Illustration)... 289
Tender Wheels .................................................. 235
Tender with Eight Wheels ........................................... 25
Ten-Wheeled Locomotive for Pennsylvania Railroad .......... 46
Ten-Wheeled Locomotive Introduced ............................. 45
Ten-Wheel Passenger Locomotive. (Illustration) .......... 85, 152, 194
Test Engines with Iron and Copper Tubes ..................... 36
Test of Tubes, Summary Table .................................... 37
Thomas Iron Company, Mogul Locomotive (with Illustration) 63
Thomson, J. Edgar, Order from .................................... 32
Throttle Lever Work (with Illustration) ......................... 234, 339
Throttle Valve ..................................................... 229, 256
Throttle Work ..................................................... 339
Throwing Live Steam into Low Pressure Cylinder ............. 159
Tiku Ho Railway, Mogul Compound. (Illustration) .......... 150, 196
Time Made by Locomotive "Governor Paine" ..................... 44
Time Table Advertisement .......................................... 13
Tinning Crossheads ................................................ 161
Tires, Driving (with Illustration) ............................... 231, 285
Tires for Driving Wheels .......................................... 25
Tires Shrunken on Wheel Centres ................................... 67
Tires, Test Specification ........................................... 97
Track across the Blue Ridge ....................................... 47
Tractive Power Diagram ............................................ 91
Train of Twenty Compound Locomotives ......................... 146
Tramway Motors, New South Wales ............................... 74
Truck and Tender Wheels .......................................... 20
Truck Box Brasses ................................................. 233
Truck Box Cellars .................................................. 233
Truck Boxes (with Illustration) .................................. 233, 347
Truck Centre Pin, Engine .......................................... 233
Truck, Engine (with Illustration) ................................. 233, 319
Truck Frame, Engine ............................................... 233
Truck Springs ....................................................... 232
Truck, Tender (with Illustration) ................................. 235, 379, 381
Truck Wheels ....................................................... 233, 289
Tube Ferrules ....................................................... 229
Tubes ................................................................. 229
Tubes of Iron First Used .......................................... 36
Tubes, Test Specification .......................................... 94, 95
Tubes with Copper Ferrules ....................................... 21, 42
Types of Locomotives ............................................... 238-252

*United States Gazette, Extract* .................................... 12
United States General Government, Locomotives for ......... 56
United States Metallic Packing for Piston Rods (with Illustration) ........................................ 416
United States Metallic Packing for Valve Stems (with Illustration) ........................................ 418
NARROW-GAUGE LOCOMOTIVES.

Urbano Railway of Havana, Motor ........................................ 72
Use of Starting Valve ...................................................... 156
Useful Sentences for Cabling ............................................. 222
Utica and Schenectady Railroad, Four-Coupled Locomotive ........ 34

Vacuum Valve for Compound Locomotive (with Illustration) .157, 177, 277
Vail & Hufty, Partnership .................................................. 25
Variable Cut-off Adjustment (with Illustration) ...................... 51
Variable Cut-off Chains Substituted for Straps ....................... 52
Variable Cut-off Patents .................................................... 50
Variable Cut-off with Lever and Links ................................. 52
Variable Exhaust, Automatic .............................................. 53
Valve Motion on Early Engines ......................................... 16
Valve Motion Work (with Illustration) .................................. 299
Valve Rods ........................................................................ 232
Valve, Steam Chest or Slide .................................................. 230, 263
Valve Stem Guides and Crosshead for Compound Locomotive (with Illustration) .................................................. 297
Valve Yokes ..................................................................... 230, 263
Valves and Cocks (with Illustration) ..................................... 361
Valves, Safety .................................................................... 229
Vauclain, Samuel M., Compound Locomotive .......................... 79
Vauclain, Samuel M., Partnership ......................................... 85
Vauclain System of Compound Locomotives ............................ 147
Veronej Rostoff Railway (Russia), Contract ......................... 67

Wagon-Top Boiler Introduced ............................................... 45
Water Consumption, Diagram, Single Expansion and Compound 162
Water Evaporation, Compound Locomotives ............................ 163
Water Gauge (with Illustration) ........................................... 233, 355
Water Gauge Glass ............................................................. 233
Water Gauge Lamp (with Illustration) ................................... 233, 359
Water Leg in Fire Box .......................................................... 54
Water Rate from Indicator Diagram ...................................... 167
Water Rate per Horse-Power .............................................. 167
Water Tank (with Illustration) ............................................. 373
Wedge Bolt, Pedestal ............................................................ 231
Wedge Box, Tender ............................................................. 234
Wedge, Pedestal ................................................................ 231
Wedge, Tender .................................................................. 234
Weight of Consolidation Locomotive for Lehigh Valley Railroad 87
Weights of Locomotives ....................................................... 36
Wellington and Manawatu Railway Double Ender Compound.  (Illustration) ......................................................... 148
Wellington and Manawatu, Test ........................................... 199
"West Chester," Performance of ........................................... 23
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Maryland, Test</td>
<td>194</td>
</tr>
<tr>
<td>Western New York and Pennsylvania, Test</td>
<td>193</td>
</tr>
<tr>
<td>Western Railroad of Massachusetts, Locomotives for</td>
<td>29</td>
</tr>
<tr>
<td>Wheel Centre (with Illustration)</td>
<td>287, 289</td>
</tr>
<tr>
<td>Wheel Centres, Wrought Iron</td>
<td>79</td>
</tr>
<tr>
<td>Wheel Covers (with Illustration)</td>
<td>325</td>
</tr>
<tr>
<td>Wheels, Driving (with Illustration)</td>
<td>231, 285</td>
</tr>
<tr>
<td>Wheels, Engine Truck</td>
<td>233</td>
</tr>
<tr>
<td>Wheels, Engine Truck and Tender, Test Specification</td>
<td>96</td>
</tr>
<tr>
<td>Wheels, Tender</td>
<td>235</td>
</tr>
<tr>
<td>Whistle (with Illustration)</td>
<td>234, 357</td>
</tr>
<tr>
<td>Whistle Work (with Illustration)</td>
<td>339</td>
</tr>
<tr>
<td>White Pass and Yukon Consolidation Compound. (Illustration)</td>
<td>180</td>
</tr>
<tr>
<td>Whitney, Asa, Partnership</td>
<td>35</td>
</tr>
<tr>
<td>Williams, Edward H., Partnership</td>
<td>62</td>
</tr>
<tr>
<td>Williams, Edward H., Death of</td>
<td>88</td>
</tr>
<tr>
<td>Winans, Ross</td>
<td>29</td>
</tr>
<tr>
<td>Wood Burning Grate (with Illustration)</td>
<td>333</td>
</tr>
<tr>
<td>Wood Tender Frame (with Illustration)</td>
<td>375</td>
</tr>
<tr>
<td>Wood Tender Truck (with Illustration)</td>
<td>379</td>
</tr>
<tr>
<td>Wooden Frames Abandoned</td>
<td>25</td>
</tr>
<tr>
<td>World's Columbian Exposition</td>
<td>82</td>
</tr>
<tr>
<td>Wrist Pins</td>
<td>231, 285</td>
</tr>
<tr>
<td>Wrought Iron Driving Wheel Centre (with Illustration)</td>
<td>287</td>
</tr>
<tr>
<td>Wrought Iron Engine Truck and Tender Wheel (with Illustration)</td>
<td>289</td>
</tr>
<tr>
<td>Wrought Iron Tender Truck (with Illustration)</td>
<td>381</td>
</tr>
</tbody>
</table>