THE DEVELOPMENT OF THE AMERICAN RAIL AND TRACK, AS ILLUSTRATED BY THE COLLECTION IN THE U. S. NATIONAL MUSEUM.

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In the brief report upon the section of steam transportation for the year 1887, a statement was made to the effect that considerable information had been secured which it was hoped to use "in preparing a series of models to illustrate the beginnings and development of the English and American systems of track.

"While illustrated histories of the steamboat and locomotive are numerous, I am not aware that any systematic attempt has been made to preserve the history of the development of the systems of permanent way which, after many years of experiment, are now being reduced to a series of standards depending on the traffic." (Report of U. S. National Museum, 1887, p. 79.)

These expectations were realized to a sufficient extent to warrant the preparation of the series of original rail sections, models, and drawings to illustrate the origin and development of American permanent way for the Exposition at Cincinnati in 1888.

The interest manifested in that collection led me to present a paper entitled "The Development of the American Rail and Track" at the annual convention of the American Society of Civil Engineers, at Sea Bright, New Jersey, June 21, 1889. This will appear in the transactions of that society during the coming year.*

At the conclusion of that paper I took occasion to state that in its preparation "I preferred to confine myself to a description of such rails as are represented by original sections, models, or drawings in the section of transportation and engineering in the U. S. National Museum."

"I am fully conscious that I have been compelled to overlook many things which are of great historical interest, owing to the fact that our collection is small—only a nucleus in reality."

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*See Transactions of the American Society of Civil Engineers, April, 1890, p. 209-232.

Although some additions to the collection have since been made, a large portion of the facts here stated, together with many of the illustrations, also appear in the original paper.

GOOD TRACK AS IMPORTANT AS THE LOCOMOTIVE.

As the improved wagon roads in the past made it practicable to transfer the burden from the pack mule to the wheel vehicle, and the traveler from the saddle horse to the light, comfortable, and rapidly moving carriage, so the development of the iron railway of the nineteenth century has made it possible for us to enjoy the safety, speed, and comfort of the express train of to-day, drawn by the fleet and powerful locomotive.

In considering the improvement in methods of transportation, I am led to think that there is a tendency to overestimate the benefits arising from the invention and improvement of the locomotive, and to overlook what has been done by those who devoted time and thought to the development of the various systems of permanent way.

The improvement made in track construction in England during the first quarter of the century made the introduction of the locomotive there possible.

Trevithick's locomotive of 1804, crude as it was, would have been much more successful, and might have brought him much greater fame as one of the first inventors of the locomotive, had the track upon which it ran been constructed according to modern methods.

Long before the locomotive was a practical machine the advantages of the cast-iron tramroad were fully appreciated.

By careful calculation a distinguished London engineer, in 1802, found that while it cost 3*s.* 4*d.* per ton per mile to transport bulky freight over turnpikes, the cost on iron horse tramroads was only one-tenth, 4*d.*

George Stephenson, while president of the "British Carrying Companies," stated "that by the introduction of the horse tramroad the monthly expense of that company for coal carriage alone had been reduced from £1200 to £300.

An edition of "Wood's Treatise of Railroads," published in 1830, which was one of the earliest and most reliable standard works on railroad subjects, calls attention to the economical operation of the coal railroad, 9 miles long, near Mauch Chunk, Pennsylvania, then operated by horse power, and states that by this method "it has repaid its whole cost since 1827."

On a large proportion of the American railways projected before 1830, it was intended that horse power should be used.

In Austria the advantages of a horse tramway were also understood.

In 1828 thirty-nine miles of the horse railway from Budweis to Lintz—constructed across the mountains which separate the Moldau and the Danube—was opened to traffic. This road was extended 41 miles farther in 1832, and for many years paid a dividend of 5 per cent. upon a capitalization of $10,000 a mile, being subsequently increased to a length of 130 miles in 1839.

The modern horse railways in our cities and their suburbs earn handsome dividends by carrying passengers at a lower fare per mile than the steam railway companies find profitable.

THE IRON COAL ROAD.

The circumstances connected with the origin of the iron railroad, and particularly the relations which existed between coal, iron and the railway in the beginning, are of the greatest interest. Man's physical necessities exert a powerful influence upon the inventive faculties, and the trite proverb arising therefrom is nowhere better exemplified than in the history of the conception, birth, and growth of the railroad.

The demand for a new fuel to replace the faggot and the log was the necessity that became more and more urgent as the forest disappeared to satisfy the demands of a dense population. This condition of affairs directed thought toward devising improved methods for transporting pit coal from the collieries of Great Britain to the adjacent navigable streams or near seaports.

Although coal had been mined in England as early as the middle of the ninth century, it was not until 1259 that Henry III granted the privilege of digging coal to certain persons in Newcastle. By the beginning of the fourteenth century it had become an important article of export, and was called "sea cole," owing to the fact that it was shipped by vessels to various ports.

EARLY USE OF IRON.

Several methods of iron making were understood and practiced by the ancients.

The Bible bears evidence in many texts to the high esteem in which the iron worker was held. Tubal Cain is described in Genesis IV as "an instructor of every artifice in brass and iron." In alluding to the Israelites in Deuteronomy IV is the statement: "For the Lord hath taken you and brought you forth out of the iron furnace, even out of Egypt."

Processes of making iron were known to the Babylonians and Assyrians. The stones in the celebrated bridge said to have been built by Nitocris were held together by bands of iron kept in place by molten lead. "Among the ruins of Sargon's palace objects of iron and bronze, such as hooks and rings, chains, pickaxes, hammers, ploughshares, weapons, fragments of chariots, and tools of all sorts were picked up."

The Phœnicians, Persians, and even the Chinese were acquainted with processes of forging iron centuries before the Christian era; and in India, in the temple of Kuttub at Delhi, there stands a pillar of solid forged iron over 16 inches in diameter and nearly 60 feet high, supposed to have been erected in the third century.

But these methods must be included among the lost arts—arts lost in the great abyss of the middle ages, which swallowed up so many of the results of the skill and ingenuity of the ancient world.

But among the Greeks and the ancient nations of the Orient, as we learn from Homer, the early historians, and the latest inscriptions and archæological discoveries, iron was once regarded as a precious metal. Homer's elaborate description of the shield of Achilles, forged by Vulcan, undoubtedly shows that the art of working iron was fully understood in that semifabulous epoch.*

Iron first came into use in the arts and manufactures when Spain flourished under the Visigoths, who are said to have derived it from their ancestors, the Scythians, of whose history so little is definitely known. Spanish iron brought high prices for many years.

THE IRON INDUSTRY IN ENGLAND.

Early in the fifteenth century many blast furnaces were in existence in France, and soon afterward they were introduced in Sussex, Kent, and Surrey, in England, and this gave impetus to the iron industry of England. As the processes of extracting iron from various ores became more fully understood, the demand increased, and in order to keep up the supply great inroads were made each year upon the forests for fuel.

During the reign of Queen Elizabeth (1558–1603) the iron industry increased so rapidly that the consumption of wood became a most serious matter, as iron was then smelted exclusively by charcoal.

The destruction of the forests was so rapid that Parliament passed acts in 1558, 1581, and 1584 restricting the cutting of wood for charcoal, and thus the iron industry languished for over a century.

In the mean time thought had been directed to the processes of smelting iron with pit coal. Sturdevant's method, although patented in 1611, was not practicable; and Dudley, who eight years after solved the problem with some success, was so much abused by the charcoal smelters, that fearing bodily injury he too abandoned the business. Nothing further seems to have been done toward using coal for smelting iron ore in England during the seventeenth century.

THE IRON INDUSTRY IN AMERICA.

As early as 1621 a considerable quantity of iron was produced in Virginia, and that colony led the industry until 1628, when Massachusetts forged ahead.

As wood fuel was plenty in America the industry grew so rapidly that Parliament passed an act in 1660 prohibiting the exportation of

*Manual of Oriental Antiquities, Ernest Babelen, p. 125.

iron from the colonies except in English ships; and in 1679 a duty of 10s. was imposed by the British Government upon each ton of pig iron exported.

In 1750, about 3,500 tons of pig iron having been imported into England from America, a law was passed by Parliament removing this duty, but prohibiting all persons in the colonies, under penalty of £200, from erecting a forge or working a tilt hammer or a rolling mill. This was one of the "grievances" that instigated the Declaration of Independence.

The historian Bancroft, commenting on this fact, says:

> America abounded in iron ore; its unwrought iron was excluded from the English market, and its people were rapidly gaining skill at the furnace and forge. In February, 1750, the subject engaged the attention of the House of Commons. After a few days' deliberation a bill was brought in which permitted American iron in its rudest forms to be imported duty free; but now that the nailers in the colonies could afford spikes and large nails cheaper than the English, it forbade the smiths of America to erect any mills for slitting or rolling iron, or any plating forge to work with a tilt.*

In 1761 less than 17,000 tons of iron had been made in all Great Britain and over 4,500 tons had been imported from America.

COAL-MINE TRAMROADS.

The earliest railways were laid in the coal mines and from the mines to the adjacent water courses. These ways consisted of squared timber rails laid in the ground, held to gauge by cross timbers, to which they were fastened by wooden pins.

Roger North in 1672, in his biography of his brother Francis, the Lord Chancellor, describes a wooden railway which he had seen at Newcastle during the reign of Charles II, as follows: "The manner of the carriage is by laying rails of timber from the colliery down to the river exactly straight and parallel, and bulky carts are made with rowlets fitting these rails, whereby the carriage is so easy that one horse will draw 4 or 5 chaldrons of coals." The Newcastle chaldron weighed 5,936 pounds, so that one horse hauled 8 or 9 tons.

EARLY AMERICAN COAL MINES.

Coal was mined in America as early as 1770 on the James River in Virginia, and was used at the Westham foundry to manufacture shot and shell during the Revolutionary War.

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* The exact wording of the act as finally passed was as follows: "And that pig and bar iron in his Majesty's colonies in America may be further manufactured in this kingdom, be it further enacted by the authority aforesaid, that from and after the 24th day of June, 1750, no mill or other engine for slitting or rolling of iron, or any plating forge to work with a tilt hammer, or any furnace for making steel, shall be erected, or after such erection continued in His Majesty's colonies in America; and if any person or persons shall erect or cause to be erected, or after such erection continue, or cause to be continued, in any of the said colonies, any such mill, engine, forge or furnace, every person or persons so offending shall, for every such mill, engine, forge or furnace, forfeit the sum of 200 pounds lawful money of Great Britain."

Ashbel Welch, in the Presidential address at the annual convention of the American Society of Civil Engineers at Washington in 1882 states that, "About the year 1817 Josiah White and Erskine Hazard commenced the improvement of the Lehigh River, and made other preparations to inaugurate the anthracite coal trade. In 1820 they sent to market 365 tons, which was the beginning of the regular anthracite coal trade of America."

Before 1825 coal mining commenced to be an industry in the Schuylkill and Lehigh regions. In this country, as in England, the earliest railroads were built in and from the coal mines at Mauch Chunk, Honesdale, and Pottsville in Pennsylvania and Chesterfield in Virginia to the nearest navigable streams.

The first locomotive that ever turned a driving wheel on a railroad on the Western Continent was imported from England in 1829,* for use on the Delaware and Hudson Canal Company's coal road at Honesdale, Pennsylvania.

As the supply of coal was increased by improved methods of mining and cheaper means of transportation, it gradually superseded charcoal in the manufacture of iron. The cost of pig iron was reduced from £16 10*s*. in 1660 to £3 in 1760, and the price did not vary much from this until the American Revolution cut off the supply of iron that England had been receiving from the colonies. This was several years before the introduction of good steam pumping engines, which between 1775 and 1790—through the improvements and inventions made by Watt in the engines of Savery and Newcomen—reached such a degree of perfection that good steam pumps were put in every prominent colliery, and the amount of coal mined reached enormous proportions as the cost of mining it was lessened.

IRON FURNACES IN ENGLAND.

The following statement shows the growth of the iron industry in England during eighty-five years prior to the introduction of the locomotive, in 1825:

Year.	Iron.	Number of furnaces.	Production.
			Tons.
1740	Charcoal iron	59	17,350
1788	Charcoal iron	24	13,100
	Pit coal (coke)	53	48,800
1796	...do	121	124,879
	Charcoal	None.	
1802	Pit coal (coke)	168	170,000
1806	...do	227	250,000
1825	...do	305	600,000

* The locomotive "Stourbridge Lion," a full-sized model of which is in the Section of Transportation and Engineering in the U. S. National Museum.

Thus, even before the successful introduction of the locomotive, coal, iron, and the railroad had become three equally important factors in the creation of the great systems of transportation, which have made our prosperity and the higher civilization of to day possible.

CAST IRON FIRST USED FOR RAILS IN ENGLAND.

The price of iron was materially reduced as coal became cheap and abundant, and at length it became possible to use it in the construction of rails. The earliest iron used in track construction was cast in plates 3 or 4 feet long, 2 or 3 inches wide, and one-half or three-fourths of an inch thick. These plates were spiked on top of the wooden stringer rail where the wear was the greatest.

As timber was dear in England at the close of the last century, many attempts were made to devise a cast-iron rail that should suit the traffic of the English tramroads.

We have in the collections several models of the cast-iron rails that were used from 1789 to 1816. A fair impression can be obtained of the crude ideas that the early English tramway contractors had in regard to rails from an examination of the drawings.

Fig. 23, cast-iron edge rail, 1789. Patented in England by William Jessop, mine engineer, and laid on a road in Loughborough. The rail was fish-bellied, and at first was not supported by a chair, the wood or

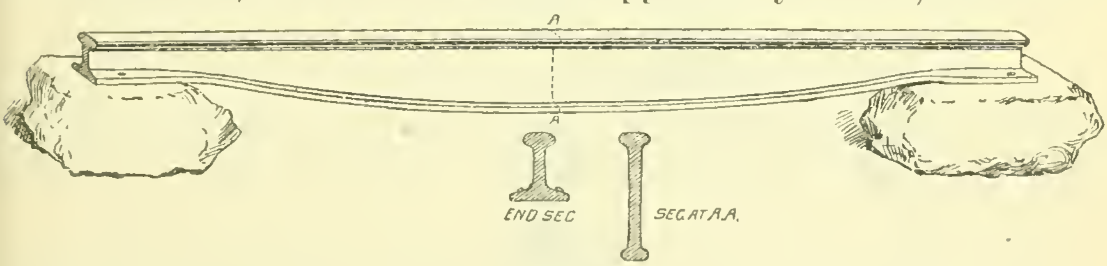


Fig. 23.
JESSOP'S PATENT EDGE RAIL. (1789.)
(From model in the U. S. National Museum.)

stone block being hewn to fit the end of the rail. Near the ends the rail had a flat projecting base, in which there were holes for the bolts which fastened them to the wooden block or sleeper.

Fig. 24, cast edge rails, 1797, with joints supported by chairs. These were the first chairs adopted, and were cast the reverse of the ends of

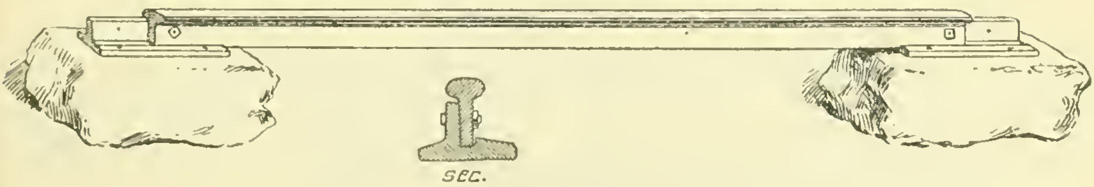


Fig. 24.
EDGE RAILS, LAWSON COLLIERY, NEW CASTLE-ON-TYNE. (1797.)
From model in the U. S. National Museum.

the rail, having two bolts through the stem of the rail at each joint. They were laid on the Lawson Main Colliery Road, New-Castle-on-Tyne, England, by Mr. Barnes, and were at first supported by timber but finally by stone blocks.

Fig. 25, cast edge rails, 1802; 4 feet 6 inches long. Invented by Mr. Wyatt, and used on the railway at the slate quarry at Lord Penrhyn's estate, near Bangor, North Wales. The general shape of the cross-section of this rail was a hexagon. At each end of the rail a dove-tail block, 2 inches long, was cast at the bottom. This was slipped into a chair, which had previously been attached by a bolt to the wooden or stone support.

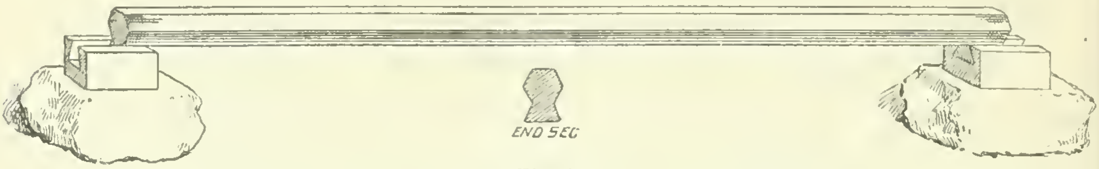


Fig. 25.
WYATT'S HEXAGONAL RAIL, BANGOR, NORTH WALES. (1802.)
(From model in the U. S. National Museum.)

Fig. 26, cast tram rail, 1803, "with flange higher in the middle and a nib under the tread to add strength." Used on the Surrey Railway, England. These rails had a rectangular notch, half square, in the ends, the joints being completed by one square-headed iron spike, which was counter-sunk.

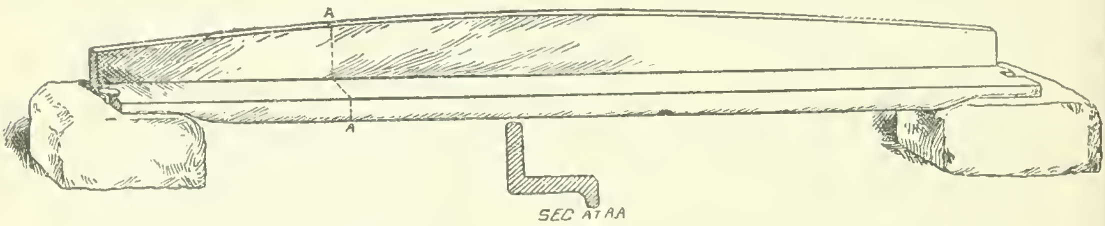


Fig. 26.
TRAM RAIL, SURREY RAILWAY. (1803.)
(From model in the U. S. National Museum.)

Fig. 27, cast rail with concave top, 1803. To be used also by road wagons and to be imbedded in common roads. This rail, patented by Josiah Woodhouse, was fastened to transverse cross ties by bolts slipped into slits through the base.

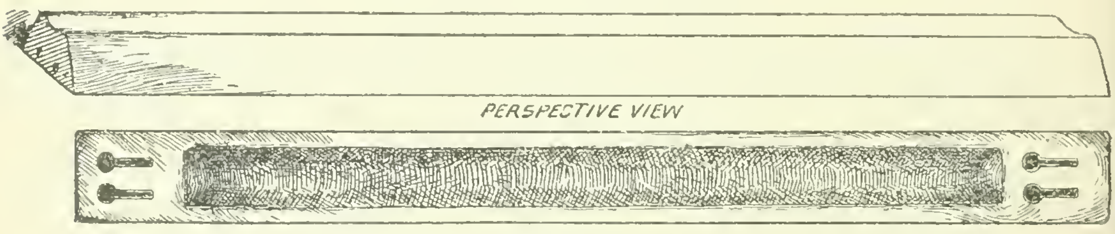


Fig. 27.
WOODHOUSE'S PATENT CONCAVE RAIL FOR WAGONS.
(From model in the U. S. National Museum.)

Among the most interesting relics in the collection are two of the cast tram rails, 3 feet long, from the track from Penydarren Works to Glamorgan, near Aberdare Junction, Wales. These rails were a portion of the original track upon which Trevithick's first locomotive, to help man, ran in 1804, and was a gift of J. W. Widdowson, Esq., London and Northwestern Railway of England, to the U. S. National

Museum. A drawing of these rails with the stone supports, one of which is also in the collection, is shown in Fig. 28.

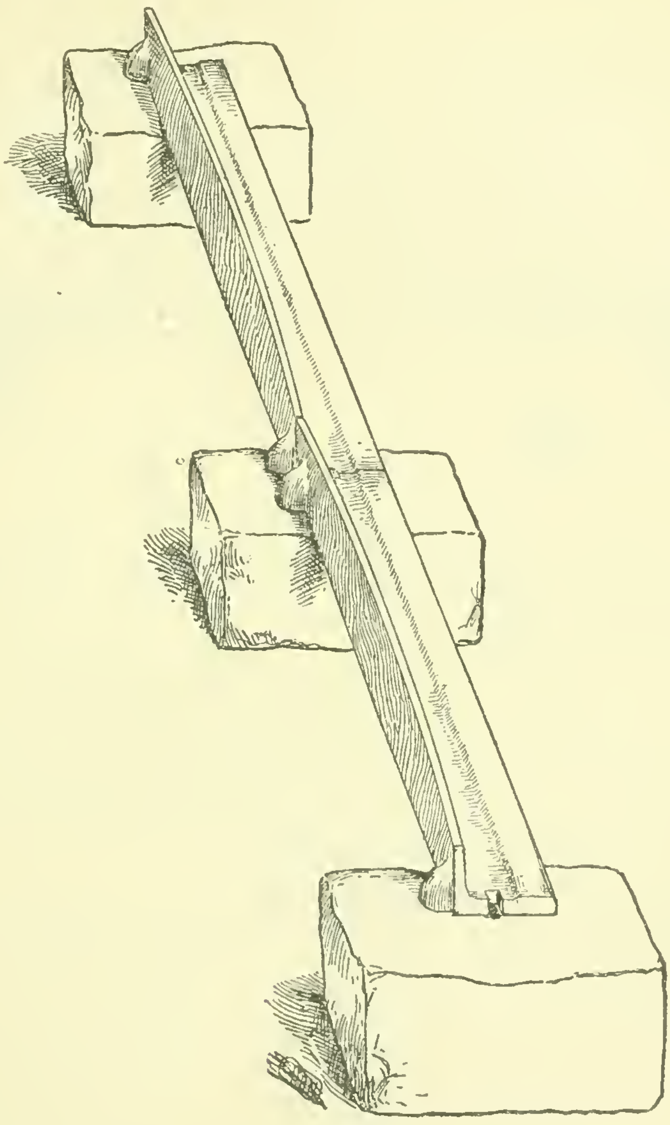


Fig. 28.
TRAM RAIL, PENYDARREN WORKS TO GLAMORGAN CANAL, WALES. (1804.)
(Original in the U. S. National Museum.)

Fig. 29 is drawn from a model of a cast tram rail, designed to be laid without bolts or spikes. Charles Le Cann, of Llannelly, Wales, in 1808,

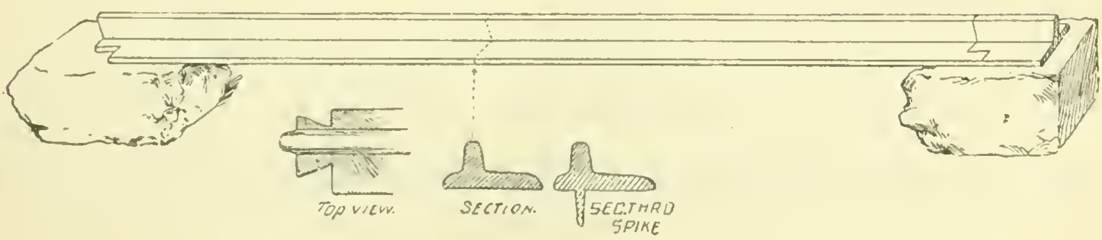


Fig. 29.
TRAM RAIL, DESIGNED BY CHARLES LE CANN, LLANNELLY, WALES. (1801.)
(From model in the U. S. National Museum.)

received a premium of 20 guineas from the Society of Arts for the invention of this rail, which was ingenious in construction. Projecting pins, pyramidal in shape, were cast on the bottom of the tram rail at the points where the stone supports came under the rail, the joints being dovetailed into each other; the need of any other form of joint fixture was thus dispensed with. These rails were about 5 inches wide, and weighed 42 pounds per yard.

Fig. 30 is from a model of a cast rail patented by Losh and George Stephenson, of Killingsworth, England, in 1816. A half-lap joint was used, through which a horizontal pin was passed transversely and

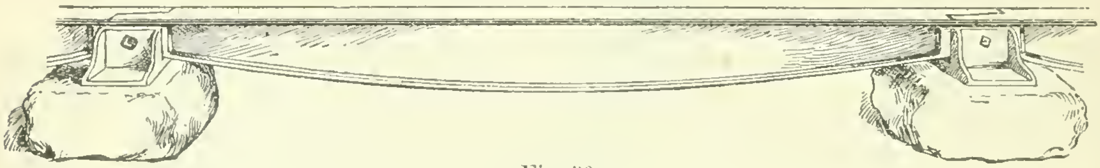


Fig. 30.
EDGE RAIL, PATENTED BY LOSH AND STEPHENSON, LAID ON STOCKTON AND DARLINGTON RAILROAD, 1825. (1816.)
(From model in the U. S. National Museum.)

joined the rails together, at the same time fastening them to the cast-iron chair. A large portion of the Stockton and Darlington Railroad was laid with this rail in 1825.

ROLLED IRON RAILS INTRODUCED.

Early in this century inventive genius increased the power of the stationary engine and the efficiency of the steam blast and of the machinery for working and handling iron.

The puddling furnace, first used in 1784, was radically improved by Henry Cort about the beginning of the century. He also invented and introduced the rolling mill about the same time, so that it became pos-

Fig. 31.
LORD CARLISLE'S WROUGHT-IRON RAIL. (1811.)
(From model in the U. S. National Museum.)

sible to roll iron rails cheaply. These were at first rolled in lengths of about 12 feet. Drawings from the models of the early English rolled rails are shown.

Fig. 31 is a bar rail laid in Lord Carlisle's quarries, 1811.

Fig. 32, wrought iron rail, patented 1820, by John Birkenshaw, of the Bedlington Iron Works, England. A clause in the patent specifi-

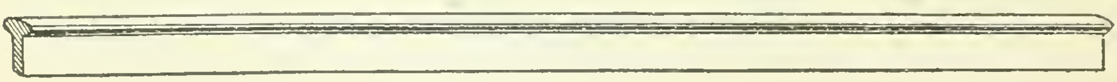


Fig. 32.
WROUGHT-IRON RAIL, PATENTED BY JOHN BIRKENSHAW. (1820.)
(From model in the U. S. National Museum.)

cations reads: "The upper surface to be slightly convex to reduce friction. The upper part to rest on supporting blocks, chairs, and sleepers. The wedge form is used because the strength of a rail is always proportioned to the square of its breadth and depth. Hence this (wedge) form of rail possesses all the strength of a cube equal to its square. The joints are made with a pin." Birkenshaw showed great ingenuity in designing the rolls by which these rails were fairly rolled in lengths of 18 feet. Cast bars were soon after dispensed with. The model is made from drawings and specifications, English patent No. 4503, to John Birkenshaw, sealed October 23, 1820.

Fig. 33, wrought-iron edge rail with fish-bellied web. These rails were used by Stephenson in 1829 in laying the Liverpool and Man-

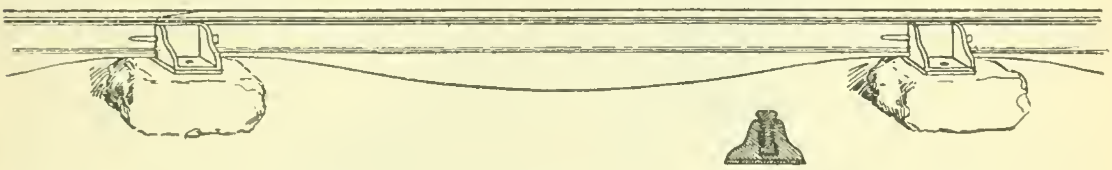


Fig. 33.
FISH-BELLY RAIL, DESIGNED BY GEORGE STEPHENSON AND LAID ON THE MANCHESTER AND LIVERPOOL RAILWAY. (1829.)
(From model in the U. S. National Museum.)

chester Railway. Chairs used at joints; rails 15 feet long; supports 3 feet apart; weighed 35 pounds per yard.

Fig. 34 shows a cross section of the original rail laid on the old Portage Railroad over the Allegheny Mountains in Pennsylvania. These

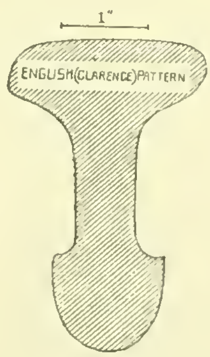


Fig. 34.
ENGLISH ROLLED RAIL, CLARENCE PATTERN, LAID ON THE OLD POSTAGE RAILWAY OF PENNSYLVANIA, 1833.
(From original in the U. S. National Museum.)

rails were imported from England in 1832 and laid in 1833. A section of this rail is in the collection. A portion of the New Jersey Railroad (from Jersey City to New Brunswick) was also laid with T rails of the fish-belly pattern, similar to Fig. 33.

In Fig. 35 the dotted line indicates the depth of the rail between the ties. The plate is from an original rail in the collection which was laid

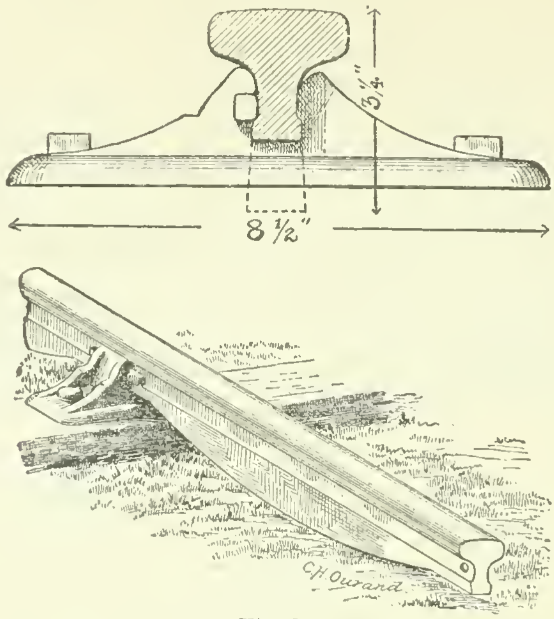


Fig. 35.
ENGLISH FISH-BELLY RAIL, LAID ON THE NEW JERSEY RAILROAD NEAR NEWARK, 1832.
(From original in the U. S. National Museum.)

near Newark, New Jersey, in 1831. It was the original design to lay the whole Portage Railroad with stone blocks and T rails.

THE ORIGIN OF THE AMERICAN RAIL AND TRACK.

In 1825-'27 a few isolated coal tramroads existed in the mining regions in Pennsylvania and Virginia and in the stone quarries in Massachusetts. These roads were laid with wooden rails, capped with thin merchant bar iron. About this time the Pennsylvania Society for the Promotion of Internal Improvement sent an engineer abroad to examine the English railways. The fully illustrated report made by William Strickland, published during the year 1826, shows that rapid advances in track construction had been made in Great Britain during the preceding decade, notwithstanding the fact that comparatively few locomotives were at work and only one railway for general traffic had been opened.

This report, without doubt, contained the most trustworthy information obtainable at that time by American railway projectors.

But America presented a very different problem from England to the pioneer railway builders. England was an old country, rich in commerce and foremost in manufactures, of comparatively small area and very densely settled, having a population of nearly two hundred to the square mile of territory, while the population of the whole United States was less than four to the square mile. In the seven States, Connecticut, Massachusetts, New York, New Jersey, Pennsylvania, Delaware, and Maryland, where most of the early railways were projected, the average population was a little over thirty-five to the square mile.

ENGLISH AND AMERICAN ENGINEERS.

The British railway projectors had the advantage of being able to call into their service a trained force of civil engineers. Many of these engineers were connected with well-organized scientific societies, or were generally experienced in the construction of public works, and were familiar with what had been done for years on the coal tramroads; men on whose judgment the wealthy capitalist was willing to supply the money for the proposed improvement. England also had numerous machine-shops fairly well equipped with tools and stationary engines, and many coal mines and iron foundries in operation, which made it possible to obtain without difficulty the material for laying the tracks with heavy rails firmly attached by strong chairs to the sleepers that were imbedded in stone ballast.

With the exception of making the rail heavier, and using steel instead of iron, and substituting an iron for the wooden cross-tie, and strengthening the splice chair, there has been no great change in the English system of track laying in the last fifty years.

Many of the civil engineers who were first called into the service of the American railroads were connected with the Army Engineer Corps, having obtained their training at West Point, the only institution in the United States where engineering was taught during the first quarter of the century. In many cases these officers were detailed for a term of years to the "Board of Engineers for Internal Improvements"* to make surveys for various projected roads and canals. The preliminary surveys for the Camden and Amboy, the Pennsylvania, and the Baltimore and Ohio Railroads were made with the assistance of officers of this Corps.

In some cases, however, these surveys were made by canal or road engineers who had obtained experience in canal and turnpike construction. On the railroads then built the curves and gradients were frequently sharp and steep, as few cuts or fills were made, and these cheap roads were quickly extended, through a rapidly growing country, with a view to connect the navigable water courses, and to unite with the steam-boat companies in forming "through lines." By the aid of these roads the Western and Southern States rapidly increased in population and commercial prosperity. In 1832 the South Carolina Railroad from Charleston to Hamburg, 135 miles long, which was then the longest railroad in the world, was a continuous trestle work, with rails of squared timber, capped with strap iron, framed to the top of posts, where grading would have been necessary.

*The Board of Engineers for Internal Improvements received their instructions directly from the President of the United States, 1824–'32.

AMERICA WITHOUT ROLLING MILLS AT THE BEGINNING OF THE RAILROAD ERA.

When the corner-stone of the Baltimore and Ohio Railroad was laid in 1828, there was not a rolling mill in all the United State where rails of the character laid on the Stockton and Darlington Railroad could be rolled; in fact, the only rails rolled in America for several years after was the strap rail of merchantable bar iron 2½ inches wide and five-eighths of an inch thick, the holes for the spikes often being drilled by hand.

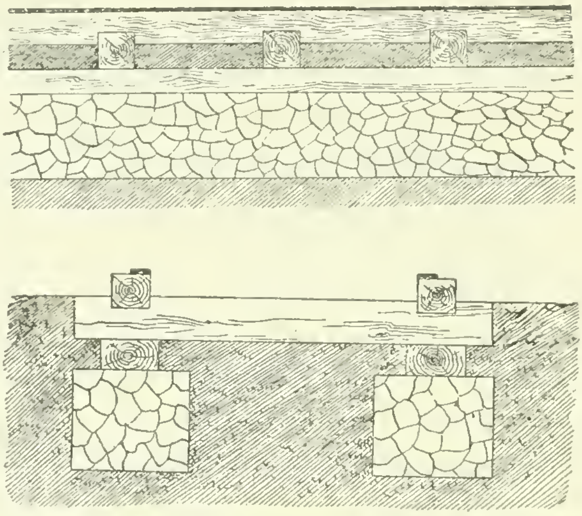


Fig. 36.
WOODEN STRINGER AND STRAP RAIL, ALBANY AND SCHENECTADY RAILROAD, 1837.
(From a drawing in the U. S. National Museum.)

On the Albany and Schenectady road strap rail was laid on longitudinal sleepers of wood, supported on trenches filled with broken stone. (See Fig. 36.)

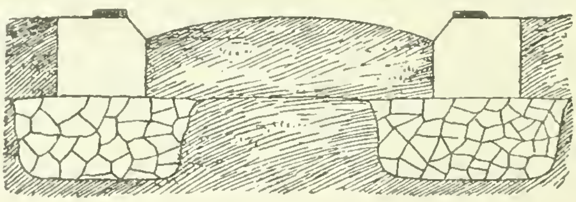


Fig. 37.
STONE STRINGER AND STRAP RAIL, BALTIMORE AND OHIO RAILROAD, 1833.
(From original rail and stone block in the U. S. National Museum.)

On the Baltimore and Ohio Railroad, and the Columbia road in Pennsylvania, the strap rail was attached to the edges of stone blocks, which were laid on trenches filled with broken stones; the corners of the stone stringers were chamfered. (See Fig. 37.)

A thick rectangular rail laid on the Baltimore and Port Deposit Railroad in 1838 is illustrated in Fig. 38, from a drawing in the collection.

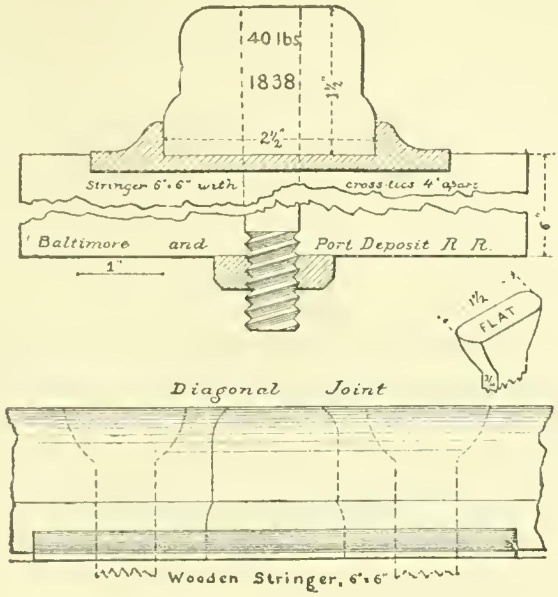


Fig. 38.
THICK RECTANGULAR RAIL, LAID ON THE BALTIMORE AND PORT DEPOSIT RAILROAD, 1838.
(From drawing in the U. S. National Museum.)

Roads, such as the Camden and Amboy in New Jersey, Boston and Providence, Philadelphia and Germantown, and the Pennsylvania (then under State control), which did not adopt this construction, were compelled to obtain their edge rails and rail fastenings from England.

The following memorial presented to the Twentieth Congress (H. R. Doc. No. 206) by the Baltimore and Ohio Railroad Company, and referred to the Committee on Roads and Canals March 17, 1828, is of the greatest interest in this connection.

To the Senate and House of Representatives of the United States in Congress assembled:

The memorial of the president and directors of the Baltimore and Ohio Railroad Company respectfully sheweth: That your memorialists have it in contemplation, and are at this time taking measures, to construct a railroad, with at least two sets of tracks, from the city of Baltimore to the Ohio River, which will, it is estimated, unavoidably require not less than fifteen thousand tons of malleable iron.

Your memorialists, taking into consideration the actual quantity of this indispensable article now annually manufactured in our own country, and further considering the numerous lines of railroads already projected in different parts of the United States, are confirmed in the opinion that it will be difficult, if not impossible, to procure amongst ourselves a sufficient quantity for these numerous undertakings, and, consequently, that an enormous enhancement of the present price must be the inevitable consequence unless supplies to a considerable extent be drawn from abroad; which enhancement of an article so necessary both in the manufacturing and agricultural operations of the country would manifestly be injurious to both these important interests.

Your memorialists are persuaded that so enlightened a body as the Representatives of the people of the United States are fully aware of the vast importance of the undertaking in which this company have embarked. It is indeed an enterprise in which every section of our country has a deep and vital interest. Its direct effect upon the prosperity of the nation, if successfully accomplished, and its beneficial influence in perpetuating the happy union of these States, is perceived and appreciated by all; at the same time it should not be overlooked that this great work, of such deep national concernment, and pregnant with such important consequences, has been undertaken, and so far conducted, by individual enterprise, and is still almost exclusively dependent upon private resources for its accomplishment.

Under these considerations your memorialists take leave respectfully to ask of the National Legislature for the passage of an act authorizing the Baltimore and Ohio Railroad Company to import from abroad, if it should be found needful, such supplies of iron and iron machinery as may be requisite for the construction of the proposed road, free of duty.

In presenting these views of an object essentially national to the representatives of their country, your memorialists rely on the wisdom and patriotism of Congress to afford such relief as may be deemed proper, either by an exemption from duty or by a drawback upon the material actually used in the construction of the road; at the same time they confidently believe that in granting the indulgence now asked for the best interests of the nation will be substantially promoted, whilst no injury whatever will accrue either to the manufacturing, agricultural, or other important interests of the country.

Signed on behalf of the Baltimore and Ohio Railroad Company.

P. E. THOMAS,
President.

The half century from 1825 to 1875 may be called the experimental era of the American railroad, since the experience obtained during that time has finally led to the adoption throughout the whole country of an almost uniform standard of track construction, depending upon the traffic. To trace the changes in form and the development of the modern American rail during this period is of the greatest interest.

THE FIRST RAIL ROLLED WITH A BASE.

From an examination of the minutes of the board of directors of the Camden and Amboy Railroad, September, 1830, I find that in the instructions given to Robert L. Stevens, president and chief engineer of that company, who had been ordered to visit England to inspect and report upon railroad matters there, he was directed to purchase "all iron rail," which the management of that company preferred to the wooden rail plated with strap iron.

Mr. Stevens sailed a few days later, and it was during this voyage that he designed the first rail ever rolled with a base, whittling several model sections out of wood, which he obtained from the ship's carpenter.

He was familiar with the Birkenshaw rail, with which the best English roads were then being laid, but he saw that, as it required an expensive chair to hold it in place, it was not adapted to our country, where metal workers were scarce and iron was dear. He added the base to the T rail, dispensing with the chair. He also designed the "hook headed" spike, which is substantially the railroad spike of to-day, and the "iron tongue," which has been developed into the fish-bar, and the rivets, which have been replaced by the bolt and nut, to complete the joint.

A fac-simile of the letter which he addressed to the English iron masters a short time after his arrival in London was published in the Report on the Section of Transportation, 1887 (page 79). It contains a cross section, side elevation, and ground plan of the rail for which he requested bids. The letter reads:

LIVERPOOL, *November* 26, 1830.

GENTLEMEN: At what rate will you contract to deliver at Liverpool, say from 500 to 600 tons of railway, of the best quality iron rolled to the above pattern in 12 or 16 feet lengths, to lap as shown in the drawing, with one hole at each end, and the projections on the lower flange at every 2 feet, cash on delivery?

How soon could you make the first delivery, and at what rate per month until the whole is complete? Should the terms suit and the work give satisfaction a more extended order is likely to follow, as this is but about one-sixth part of the quantity required. Please to address your answer (as soon as convenient) to the care of Francis B. Ogden, consul of the United States at Liverpool.

I am, your obedient servant,

ROBERT L. STEVENS,
President and Engineer of the Camden and South Amboy Railroad and Transportation Company.

The base of the rail which he first proposed was to be wider where it was to be attached to supports than in the intervening spaces. This was afterwards modified, so that the base was made one width, 3 inches, throughout. Mr. Stevens received no favorable answer to his proposals, but being acquainted with Mr. Guest (afterwards Sir John Guest), then a member of Parliament and proprietor of large iron works in Dowlais, Wales, he prevailed upon him to have the rails rolled at his works. Mr. Guest became interested in the scheme and accompanied Mr. Stevens to Wales, where the latter gave his personal supervision to the construction of the rolls. After the rolls were completed the Messrs Guest hesitated to have them used, through fear of damage to the mill machinery, upon hearing which Mr. Stevens deposited a handsome sum guaranteeing the expense of repairing the mill in case it was damaged. The receipt for this deposit was preserved for many years among the archives of the Camden and Amboy company. As a matter of fact, the rolling apparatus did break down several times. "At first," as Mr. Stevens in a letter to his father, which I have seen, described it, "the rails came from the rolls twisted and as crooked as snakes," and he was greatly discouraged. At last the mill men acquired the art of straightening the rail while it cooled. The first shipment, consisting of 550 bars, 18 feet long, 36 pounds to the yard, arrived in Philadelphia on the ship *Charlemagne* May 16, 1831. The weight of the next shipment, several months afterwards, was increased to 42 pounds per yard, the rail being 3½ inches high. Over 30 miles of this rail was immediately laid down. For sections of rail as designed and rolled see Fig. 39.

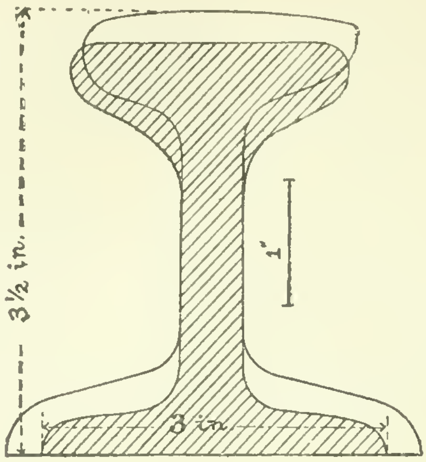


Fig. 39.

STEVENS RAIL ROLLED WITH CONVEX TOP AND BASE, DESIGNED BY ROBERT L. STEVENS, 1830, GENERALLY USED ON AMERICAN RAILROADS SINCE 1836.

Shaded section shows rail as originally designed, 1830. Section not shaded shows rail as rolled, 1831.

(From original in the U. S. National Museum.)

This rail was fastened to stone blocks with hook-headed spikes; at the joints were iron tongues fastened to the stem of the rail by rivets put on hot. This was the standard rail of the Camden and Amboy Railroad, 1831–'40.

From a letter written by Francis B. Stevens to James M. Swank, esq., special agent of statistics, dated Hoboken, New Jersey, March, 1882, the following extracts are taken :

I have always believed that Robert L. Stevens was the inventor of what is called the T-rail, and also of the method of fastening it by spikes, and I have never known his right to the invention questioned.

Mr. Stevens's invention consisted in adding the broad flange on the bottom, with base sufficient to carry the load, and shaped so that it could be secured to the wood below it by spikes with hooked heads, thus dispensing with the cast-iron chair, and making the rail and its fastening such as it now is in common use.

In the year 1836, and frequently afterwards, he spoke to me about his invention of this rail. The Camden and Amboy road laid with this rail was opened October 9, 1832, two years after the opening of the Manchester and Liverpool Railroad. Of this I was a witness. This rail, long known as the old Camden and Amboy rail, differed but little, either in shape or proportions, from the T-rail now in common use, but weighed only 36 pounds to the yard. For the next six or eight years after the opening of the Camden and Amboy Railroad it was little used here or abroad, nearly all the roads built in the United States using the flat iron bar, about 2½ by ⅝ inches, nailed to wooden rails, the English continuing to use the chair and wedges.

My uncle always regretted that he had not patented his invention. He mentioned to me upward of forty years ago that when advised by his friend, Mr. F. B. Ogden, the American consul at Liverpool, who was familiar with the circumstances of his invention, to patent it, he found that it was too late, and that his invention had become public property.

A few years after,* on much of the Stevens rail laid on the Camden and Amboy Railroad, the rivets at the joints were discarded and the bolt with the screw thread and nut, similar to that now used, was adopted as the standard. (See Fig. 40.)

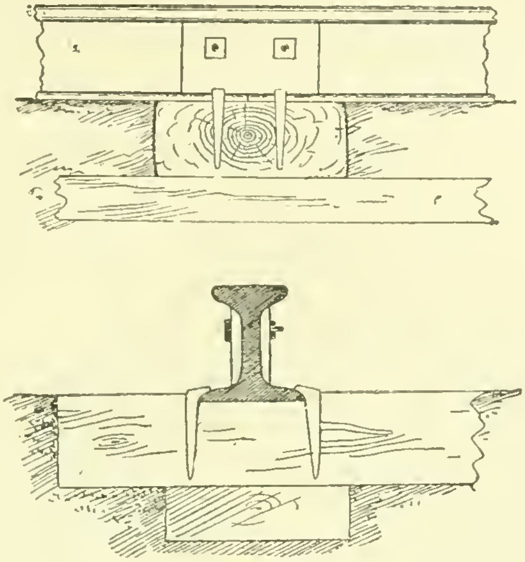


Fig. 40.
STANDARD TRACK OF THE CAMDEN AND AMBOY RAILROAD, 1837.
(From a drawing in the U. S. National Museum made from an engraving in "Engineering in North America" by G. Stevenson, London, 1837.)

Fig. 41 shows how this rail was used on a superstructure on the piling through meadows and marshy ground.

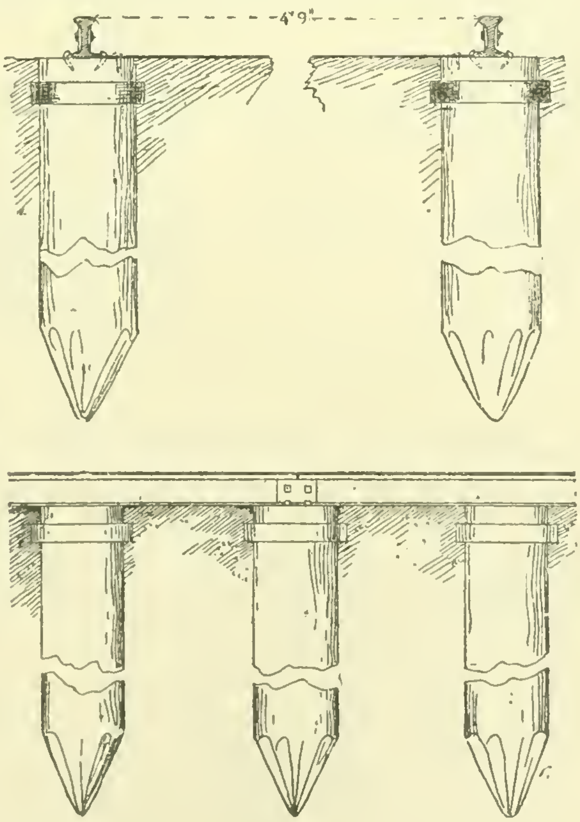


Fig. 41.
TRACK OF THE CAMDEN AND AMBOY RAILROAD. RAILS LAID ON PILING THROUGH MARSHES, 1837.
(From a drawing in the U. S. National Museum.)

* See Stevenson's Engineering in America, 1837.

The Stevens rail did not come into general use for several years, the next road to adopt it being the Boston and Providence, about 1840.

On the Boston and Lowell Railroad, Massachusetts, the fish-bellied rail was laid in chairs on stone blocks. As late as 1847 the Hudson River road used the Stevens rail, supported by chairs, but these were soon afterwards discarded.

THE FIRST AMERICAN TRACK.

Mr. Francis B. Stevens also informs me that in 1835 he was employed by the Camden and Amboy company to make a profile of the road bed from South Amboy to Bordentown. At that time there were many places (the longest being a piece 2 miles long, from the wharf at Amboy to Deep Cut) where the Stevens rail was spiked to the cross-tie according to the present practice. This method was at first resorted to as a temporary expedient, on account of the delay in getting stone blocks from Sing Sing. In the meantime it was found that the wood ties were more satisfactory, and in a year or two all the stone blocks were replaced by wood ties. Without doubt the Camden and Amboy was the first railroad in the world to be laid according to the present American practice.

On other roads the wooden tie was afterwards laid on account of the high price of stone blocks and stone stringers, the use of which was originally contemplated.

Speaking of the engineering practice in this era, the late Ashbel Welch said in his presidential address to the American Society of Civil Engineers:

> American engineers have often shown that *poverty* is the mother of invention. For example, they used wooden cross-ties as a temporary substitute, being too poor to buy stone blocks, and so made good roads because they were not rich enough to make bad ones.

CAST-IRON RAILS MADE IN AMERICA.

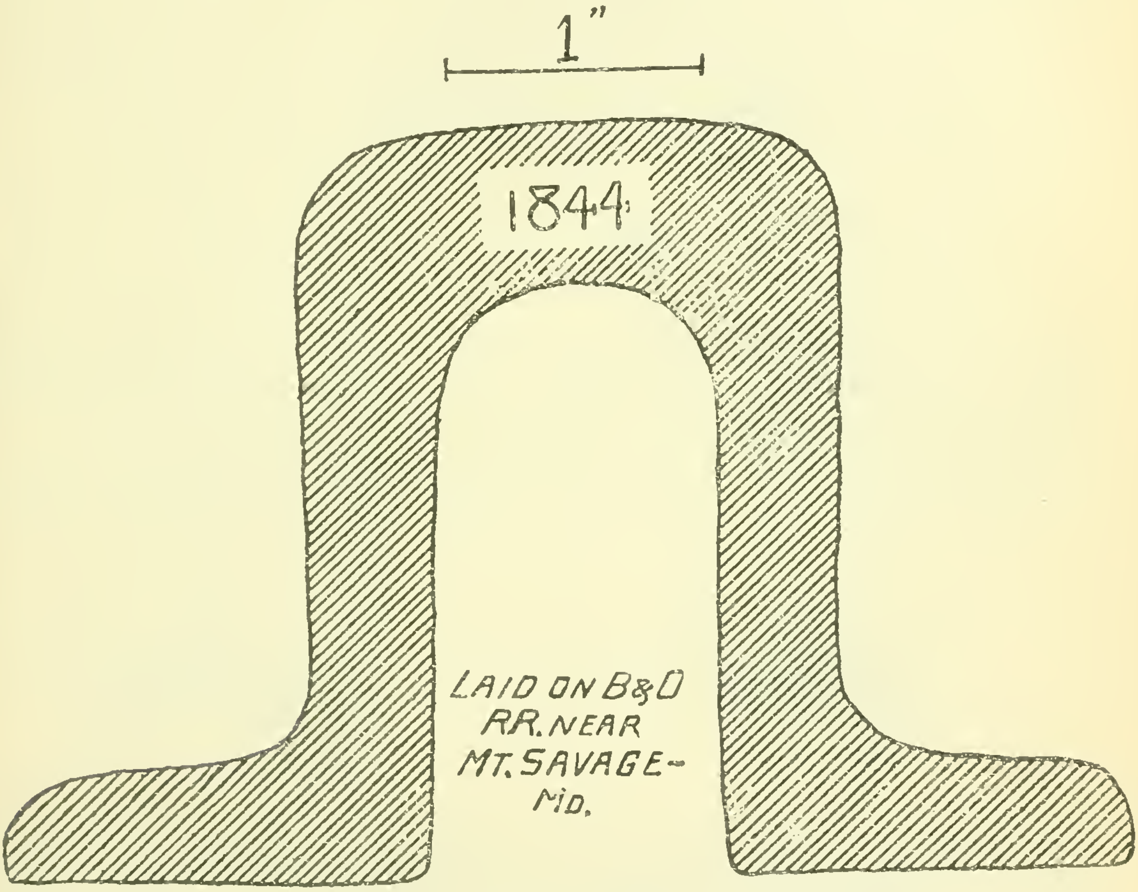
In Johnson's "Notes on the Use of Anthracite," he described tests of cast-iron rails made during 1841 at Lyman's foundry, near Pottsville, Pennsylvania. These rails were designed for colliery railways. They were only 6 feet long. For 3 or 4 inches at each end the rail had a section similar to the Stevens rail; for the remaining 5½ feet the rail was somewhat similar to the English bull-headed rail.

Previous to the year 1842, when Congress passed the celebrated high tariff law, all imported iron rails were admitted to the country almost free of duty. The tariff on manufactured iron, agreed upon by that Congress, increased the cost of English rails so much that the railways were forced to seriously advocate the erection of American rolling mills for the special purpose of making rails.

RAILS FIRST ROLLED IN AMERICA.

The first rail mill erected in this country was located at Mount Savage, Allegheny County, Maryland. The first rail was rolled in the summer of 1844. In honor of that event the Franklin Institute of Philadelphia awarded a medal to the proprietors in October, 1844.

The rail was of the ⊓ form, similar to the Evans (British) patent, and the first few hundred tons manufactured were laid on the Baltimore and Ohio Railroad, between Mount Savage and Cumberland.



—FIRST RAIL ROLLED IN AMERICA—

Fig. 42.

First Rail Rolled in America, Baltimore and Ohio Railroad, 1844.

(From a section of the original rail in the U. S. National Museum.)

A section of this rail, which weighs 42 pounds to the yard, was presented to the National Museum by the late Colonel James Randolph, for many years consulting engineer of the Baltimore and Ohio Railroad Company. Fig. 42 is drawn from the original, and is actual size.

THE STEVENS RAIL IN AMERICA.

Fig. 43 shows the Stevens rail as used on the Philadelphia and Reading Railroad in 1837

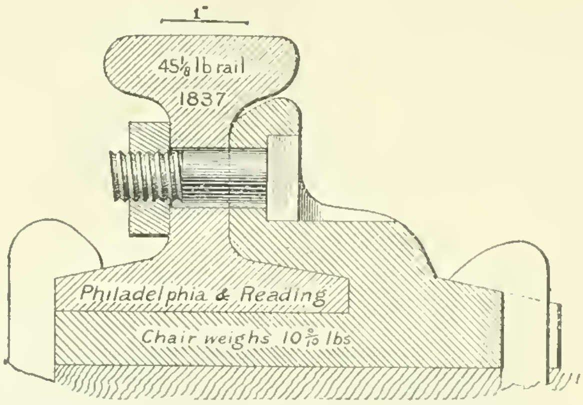


Fig. 43.
THE STEVENS RAIL SUPPORTED BY CAST-IRON CHAIR. PHILADELPHIA AND READING RAILROAD, 1837.
(From a drawing in the U. S. National Museum.)

The rail was supported by chairs. This method was believed at the time to be a considerable advance upon previous practice, but was soon abandoned on account of the increase in expense which it entailed.

The Stevens rail was laid on the Vicksburg and Jackson Railroad in 1840 (see Fig. 44). In the Southern States the longitudinal planks,

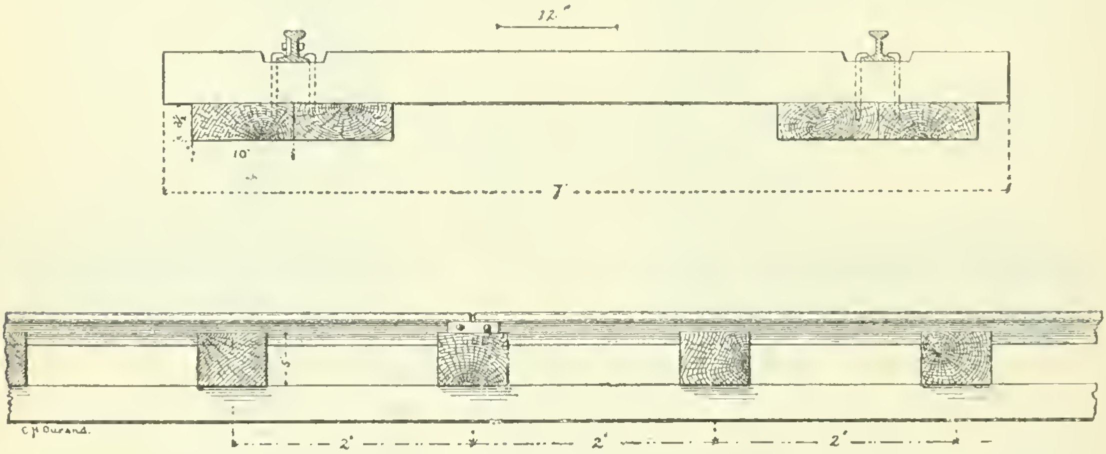


Fig. 44.
THE STEVENS RAIL AS LAID ON THE VICKSBURG AND JACKSON RAILROAD, IN MISSISSIPPI. 1841.
(From a drawing in the U. S. National Museum.)

which were placed under the ends of the cross-ties on many of the railroads, were called "mud-sills," and this name became historic during the civil war, 1861–'65.

The Stevens rail had come into general use in America before 1845, although several railway companies which had imported T-rails from England continued their use on their tracks until the rails were worn out. For this reason the T-rail without base was in use on the Boston and Worcester in 1850 (see Fig. 45), and on the Hempstead Branch of the Long Island Railroad as late as 1855 (see Fig. 46).

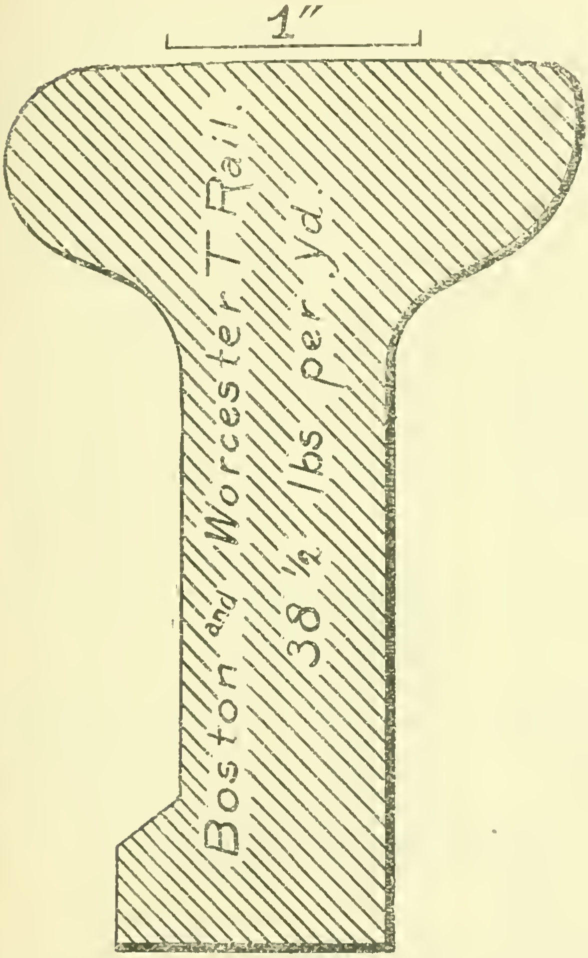


Fig. 45.
T-RAIL, BOSTON AND WORCESTER RAILROAD.
(From a drawing in the U. S. National Museum.)

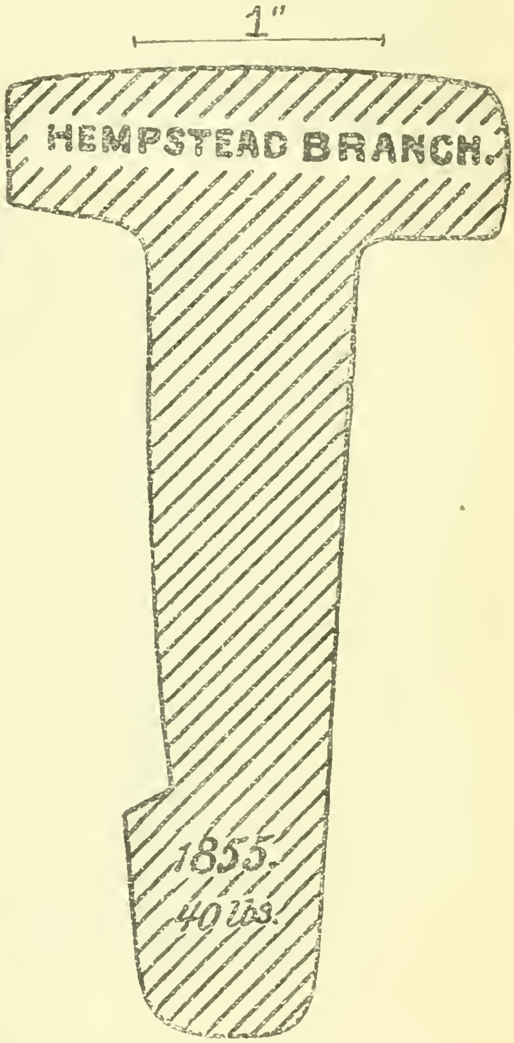


Fig. 46.
T-RAIL, HEMPSTEAD BRANCH, LONG ISLAND RAILROAD, 1855.
(From model in the U. S. National Museum.)

Every American road, however, without exception, replaced the T-rail and strap rail, by rail of the Stevens pattern, as rapidly as their financial condition permitted, continuing to import all rails from England until 1845.

THE STEVENS RAIL FIRST ROLLED IN AMERICA, 1845.

In the History of Iron of all Ages Swank states (p. 344):

The Montour Rolling Mill, at Danville, Pennsylvania, was built in 1845 expressly to roll rails, and here were rolled in October of that year the first T-rails* made in the United States, and that the first T-rail rolls in this country were made for the Montour Iron Company by Haywood & Snyder, proprietors of the Colliery Iron Works at Pottsville, the work being done at their branch establishment at Danville, Pennsylvania, 1846.

Among other early rail mills were the following, with the date when

*As the form of the English T-rail was dispensed with in America, rails of the Stevens pattern (called H-rail in 1832) have been known as T-rails for many years.

they began to roll rails: Boston Iron Works, May 6, 1846; Trenton Iron Works, Cooper & Hewitt, proprietors, June, 1846; New England Iron Company, Providence, Rhode Island, September 1, 1846; Phœnix Iron Company, Phœnixville, Pennsylvania, November, 1846.

The rapidity with which American capital was diverted in this direction, has for the last forty years been one of the great arguments used by the advocates of a high tariff for the protection of American industries.

During the year 1848 a very interesting experiment was tried by the Camden and Amboy Railroad. Arrangements were made with Cooper & Hewitt, at the Trenton Iron Works, to roll a 92-pound rail, 7 inches high, with a base 4⅝ inches wide; 15 miles of the Camden and Amboy road were laid with this rail the following year. The engineer of that company believed that he had at last solved the problem of track construction, inasmuch as this rail gave an admirable opportunity for a strong joint. By experience it was found that this rail was too rigid, and produced so much concussion by the train that the ends soon hammered out, and where the ballasting was imperfect great damage was caused to the rolling stock; consequently the rail was soon after taken up. Much of this old rail found its way to the cities, where it was bought by architects and contractors for building purposes.*

The fact that this rail was rolled successfully resulted in the introduction of the "I" beam for architectural purposes, Cooper & Hewitt having done a large business at the New Jersey Iron Works, at Trenton, in this line ever since that time. Fig. 47 is drawn from a section

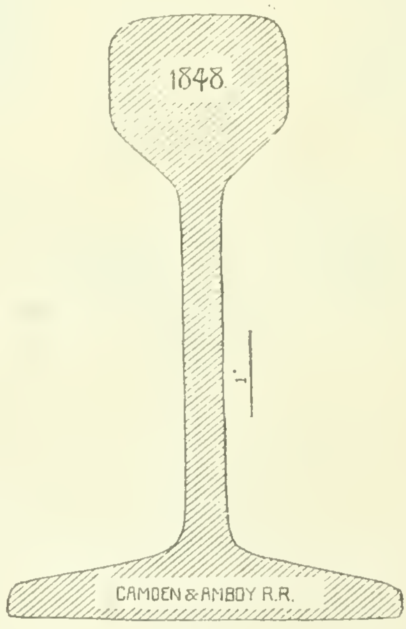


Fig. 47.
92-POUND RAIL, 7 INCHES HIGH, CAMDEN AND AMBOY RAILROAD, 1848.
(From original section in the U. S. National Museum.)

of this rail in the collection. It was laid between Bordentown and Burlington in 1849.

*Among other places, many of these rails were used for beams in the United States Mint at Philadelphia.

PEAR-SHAPED RAILS.

The early American T-rails were made of inferior iron, and this was one of the causes that led to the adoption of the section with a pear-shaped head, with which many roads were laid during the next fifteen or twenty years.

Sections of four of the pear-shaped rails described in the report of the railroad commission of the State of New York for 1845 are in the collection.

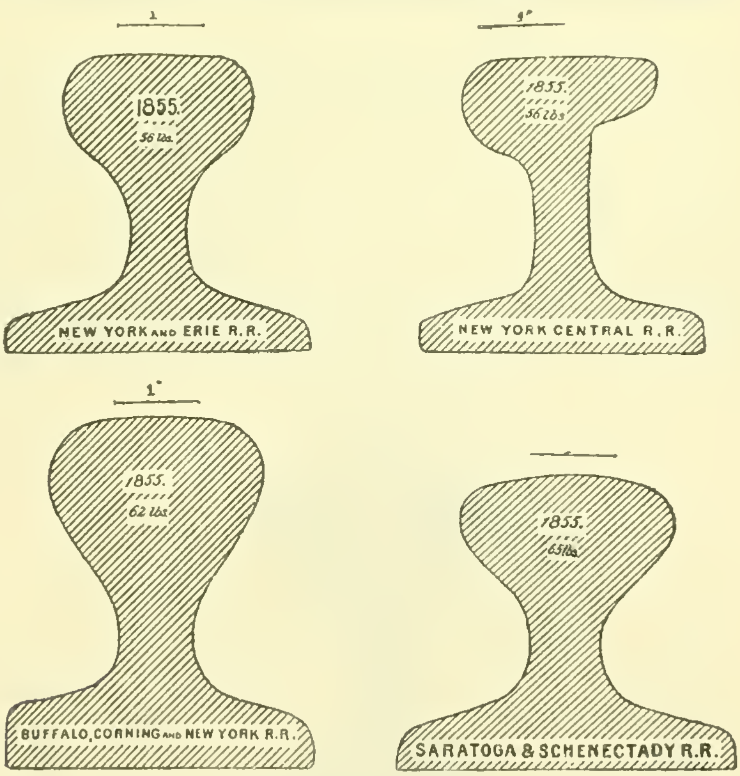
Cross-sections of these rails are shown.

Fig. 48 is a pear-shaped rail. New York and Erie Railroad. Fifty-six pounds to the yard. In use in 1855.

Fig. 49 is a pear-shaped rail. New York Central Railroad. Fifty-six pounds to the yard. In use in 1855.

Fig. 50 is a pear-shaped rail. Buffalo, Corning and New York Railroad. Sixty-two pounds to the yard. In use in 1855.

Fig. 51 is a pear-shaped rail. Saratoga and Schenectady Railroad. Sixty-five pounds to the yard. In use in 1855.



Figs. 48, 49, 50, 51.
PEAR-HEADED RAILS, 1855.
(From models, full size, in the U. S. National Museum.)

The obtuse angle between the lower side of the head and the stem of the rail made it difficult to apply a splice bar of any kind to advantage, and this fact led to the introduction of the ring joint (see Fig. 120) (one iron ring passing through two slots, one in each stem of adjacent rails and passing around under the base of the rail and held in position by a wedge driven between the ring and the rail stem). Chairs and other joint fixtures attached entirely to the base of the rail were also experimented with, but generally without satisfaction, judging from the fact that none have survived.

The difficulty in making good joints with the pear-headed rail was overcome, by some of the engineers, by planing away a portion of the head of the rail for a foot or 18 inches from each end. In Fig. 52 is

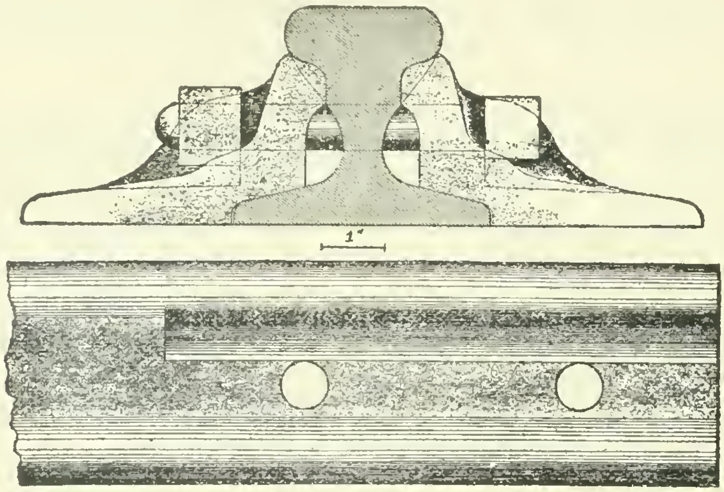


Fig. 52.
ERIE RAIL WITH ENDS STAMPED FOR ADAMS' CAST-IRON BRACKET SPLICE, 1857.
(From a drawing in the U. S. National Museum.)

shown a section of the pear-headed rail, fitted for splice bar, used on the Erie Railroad. On this rail a cast-iron angle splice, containing four bolts and measuring 9 inches in length, was used as early as 1857.

On the Pennsylvania Railroad and on the Belvidere-Delaware Railroad, as will be seen in Fig. 53, the rails in some cases were planed with

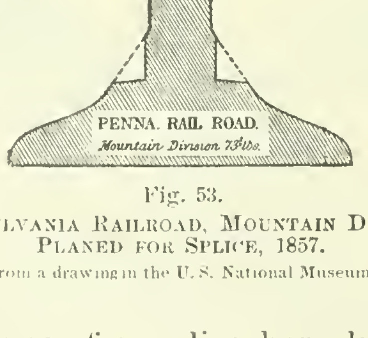


Fig. 53.
73-POUND RAIL, PENNSYLVANIA RAILROAD, MOUNTAIN DIVISION. UNDER HEAD PLANED FOR SPLICE, 1857.
(From a drawing in the U. S. National Museum.)

special reference to the use of a splice bar almost square at the rail head and base, as early as 1857.

In 1853 an interesting experiment was tried on the Boston and Lowell Railroad. After running for some time on the head (pear-shaped) of the rail it was inverted. Fig. 54 shows the effect of running on the base for three years. The dotted line indicates the original section.

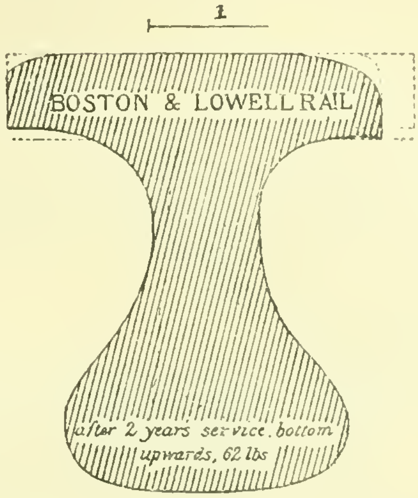


Fig. 54.
62-POUND PEAR-HEADED RAIL, BOSTON AND LOWELL RAILROAD. SHOWING WEAR AFTER TWO YEARS SERVICE, BOTTOM UPWARD.
(From a drawing in the U. S. National Museum.)

COMPOUND RAILS.

The difficulty in obtaining satisfactory joint fixtures on the American pear-shaped section led to the introduction of the compound rail.

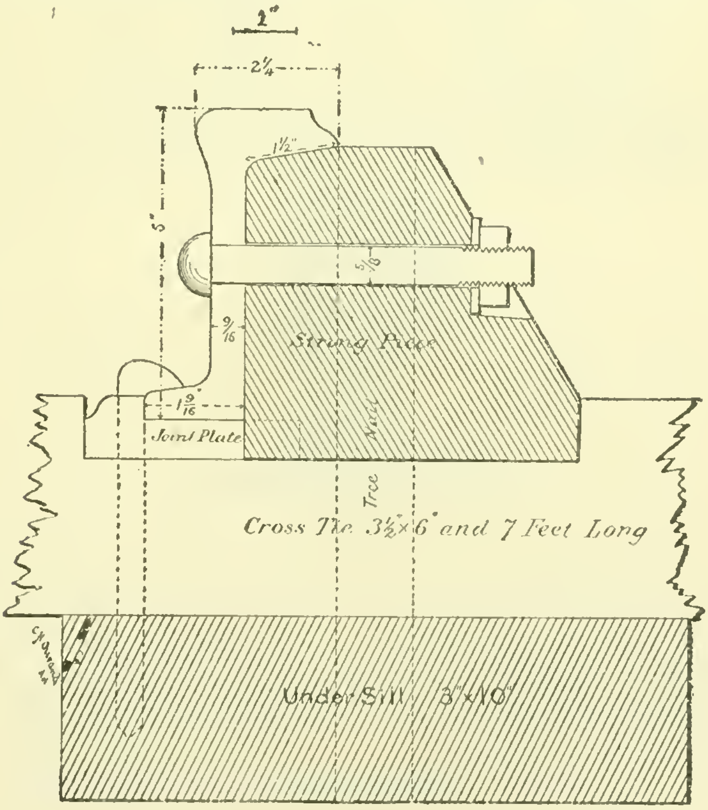


Fig. 55.
COMPOUND RAIL, WOOD AND IRON. DESIGNED BY B. H. LATROBE, 1841, FOR BALTIMORE AND OHIO RAILROAD.
(From a drawing in the U. S. National Museum.)

Fig. 55 is from a drawing of a compound rail of wood and iron designed by Benjamin H. Latrobe, in 1841, for the Baltimore and Ohio

Railroad. The Z-iron was 5 inches high and weighed 45 pounds to the yard. The track consisted of longitudinal under sills, which supported the cross-ties, 3½ by 6 inches and 7 feet long. The wooden portion of rail was made to fit closely against the stem and under the head of the Z-iron, to which it was joined by five-eighths inch bolts with screw nuts. The iron and wood stringer was laid to "break joints," so that no splice bars except a base plate was needed at the joints.

A section of an ingeniously devised all-iron compound rail laid on the Baltimore and Ohio Railroad in 1848 is shown in Fig. 56. A section of the original rail is in the collection.

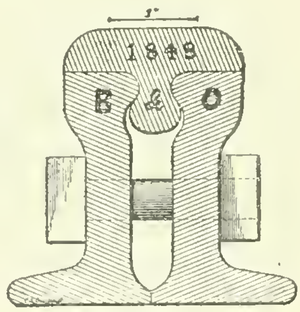


Fig. 56.
COMPOUND RAIL, BALTIMORE AND OHIO RAILROAD, 1848.
(From original section in the U. S. National Museum.)

Several of the railway companies in New York State laid a large mileage of compound rails of various-patterns.

Fig. 57 is a drawing of a compound rail weighing 75 pounds to the yard, on the New York Central Railroad in 1855.

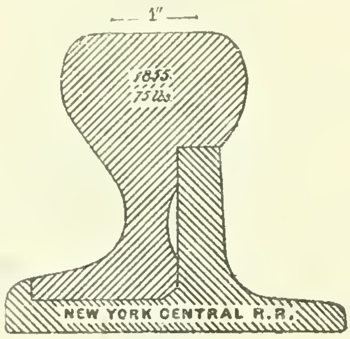


Fig. 57.
COMPOUND RAIL, NEW YORK CENTRAL RAILROAD, 1855.
(From original section in the U. S. National Museum.)

Four sections of compound rails in use in New York in 1855 are shown.

Fig. 58. Compound rail. New York Central Railroad. Sixty pounds to the yard.

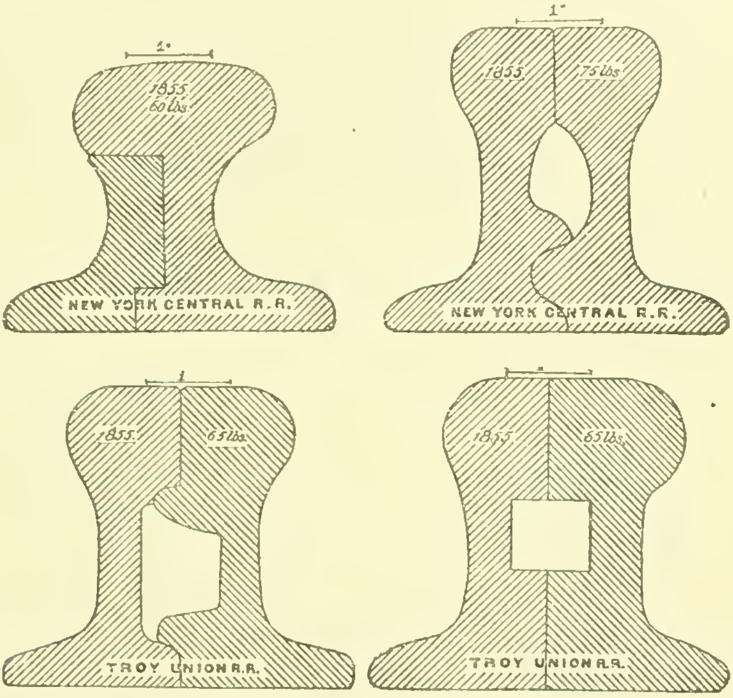
Fig. 59. Compound rail. New York Central Railroad. Seventy-five pounds to the yard.

Fig. 60. Compound rail. Troy Union Railroad. Sixty-five pounds to the yard.

Fig. 61. Wide compound rail. Troy Union Railroad. Sixty-five pounds to the yard.

Full-size models of these rails are in the collection.

When the track composed of this type of compound rails was new, it is described by those who rode upon it as being the finest track of the period. No satisfactory nut-lock was in use at that time, and as the screw-threads or rivets wore and traffic became heavier, the different parts of the rails could only be kept together by constant attention, in screwing up the nuts or putting in new rivets. As the rails laid were of iron, the wear of the inner surface was considerable, so that in a little while the track was badly damaged and the old solid rail was substituted.



Figs. 58, 59, 60, 61.
COMPOUND RAILS, NEW YORK CENTRAL AND TROY UNION RAILROADS, 1855.
(From models in the U. S. National Museum.)

It is still an unsolved question whether or not, with some improvement in the section, and made of steel and held together with the improved bolt and nut-lock, the compound rail may be the rail of the future.

POOR RAILS LAID DURING WAR TIMES.

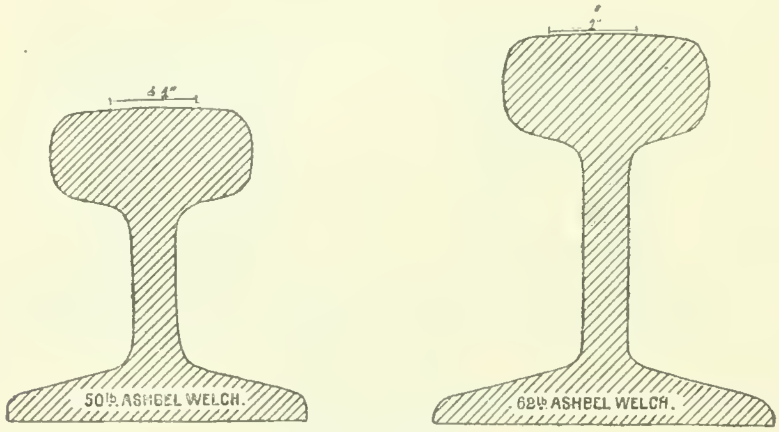
During the next ten years little seems to have been done by American railroad contractors to improve the shape of the rail or joint fixtures; in fact, during the civil war, iron was so dear that very little rail was rolled. Few new railroads were built and repairs to tracks were only made under the gravest necessity. Almost all the forms of rails which were made during these few years were designed by the proprietors of rail mills, who naturally adopted such shapes as were easy for them to make, and the railroads, when further delay was dangerous, went into the market and purchased such as were offered at the lowest price, without regard to the shape of the rail, the quality of the iron, or whether it was designed for light or heavy traffic.

THE ASHBEL WELCH RAIL.

After the close of the war in 1865, it became necessary to relay a large percentage of the mileage of almost every railroad. Upon many of the roads some rails were in use with which the roads were originally laid. The late Ashbel Welch, in "A Memoir on Rails," read before the American Society of Civil Engineers, June 10, 1874, states that "during the year 1865 the task presented itself to me of devising or selecting suitable forms of rails for the system of railroads occupying the central part of the State of New Jersey between Philadelphia and New York, of which I was the executive officer as well as engineer.

The 62-pound Ashbel Welch rail, which was rolled by the Bethlehem Iron Company during the following year, was 4½ inches high, the base being 4 inches and the stem one-half an inch thick; the angle of inclination of bearing surfaces both on the top of the base and bottom of the head being 14 degrees.

Figs. 62 and 63 are from original sections of the Welch 50-pound and 62-pound rail in the collection. Substantially this form of rail was



Figs. 62, 63.

ASHBEL WELCH RAILS, FIG. 62, 50 LBS. PER YARD; FIG. 63, 62 LBS. PER YARD, 1866.

(From original sections in the U. S. National Museum.)

adopted by the railroads in the Eastern and Middle States previous to the year 1873, although when the rails were first laid the cross-section was strongly objected to.

Mr. Welch's labors in this direction led to his being considered one of the foremost rail designers in America, and in 1873 he was appointed chairman of a committee by the American Society of Civil Engineers to report on the "form, weight, manufacture, and life of rails," the other members being M. N. Forney, O. Chanute, and I. M. St. John. The report of that committee, presented at the annual convention, June, 1874, was the most exhaustive treatise on the subject of rails published up to that time.

In Mr. Welch's memoir attached to that report, in alluding to his pattern of 1865, he states: "I made one decided mistake in this pattern by not having the outer bottom corners of the head sharp enough, or rather I yielded too much to the feeling against such an unsightly thing as an angle head." The rail proposed by Mr. Chanute in the same report is not dissimilar to the section of standard 66-pound rail now in use on the Chicago, Burlington and Quincy and several other railroads. Fig. 64 is from a drawing in the collection.

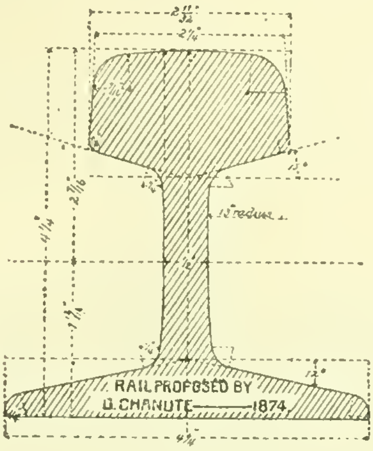


Fig. 64.
RAIL PROPOSED BY O. CHANUTE, 1874.
(From a drawing in the U. S. National Museum.)

English engineers had, in the mean time, given considerable attention to the ⊓ rail (or "box rail," as it is sometimes called) both in England and in Canada.

Imported ⊓ rails were laid as early as September, 1835, on the Wilmington and Susquehanna Railroad. In 1845 a modification of the ⊓ rail was laid on the Drogheda Railway in Ireland—the rail being compressed inwardly at the bottom until the inside corners were made to touch. In America a small quantity of a similar rail was manufactured at the Mount Savage rolling mill, called "hollow rail." This was done by heating the rail after it had been rolled to size and passing it through a set of rods designed for the purpose.*

A cross-section of this form of rail in use on the Great Western Railway of England is shown in Fig. 65, while in Fig. 66 a cross-section

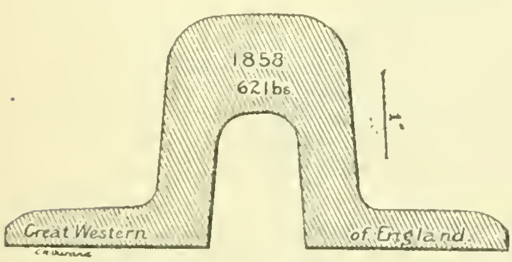


Fig. 65.
"BOX RAIL," GREAT WESTERN RAILWAY OF ENGLAND, 1858.
(From a drawing in the U. S. National Museum.)

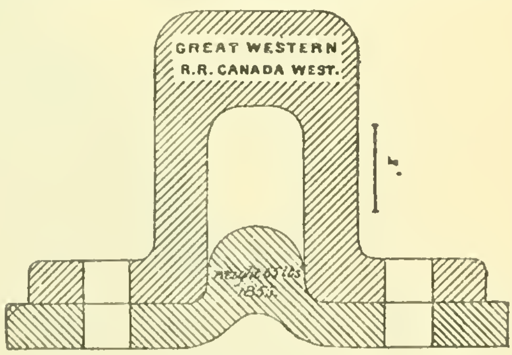


Fig. 66.
GREAT WESTERN RAILWAY OF CANADA, 1855.
(From a drawing in the U. S. National Museum.)

of the ⊓ rail with a metal shoe running the full length of the rail to which it was bolted (thus adding to its strength), as used on the Great

*If any of the rail was laid, I fail to find the fact recorded.

Western Railway of Canada, is shown. Both of these figures are from drawings in the collection.

The ∩ rail was in use in several of our Southern States during the war of 1861–'65.

It was found that the ∩ rail was almost certain to fail when laid on cross-ties, and for this reason roads, notably the Nashville and Chattanooga, that used it always favored the superstructure with the rail bearing on a longitudinal stringer instead of a cross-tie.

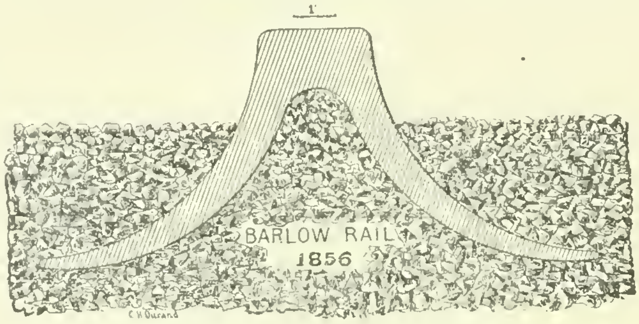


Fig. 67.
BARLOW'S "SADDLE-BACK" RAIL, 1856. LAID WITHOUT SUPPORTS.
(From a drawing in the U. S. National Museum.)

Fig. 67 is from a drawing of Barlow's "saddle-back rail" in the collection. This rail has an extreme width of 13 inches and were designed to dispense with the use of wooden ties or stringers in track construction.

The rail was laid in broken stone with tie bars 10 feet apart. Nine hundred miles of this type of rail were laid in England prior to 1858, a mile or two also were laid on the Reading Railroad in the United States. "Between 5 and 6 miles of this rail, closely riveted together, were laid in England in 1856 and were in use for several years without experiencing any difficulty from expansion."*

Fig. 68.
TRIANGULAR WOODEN STRINGER CAPPED WITH IRON, GREAT WESTERN RAILWAY OF ENGLAND, 1857.
(From a drawing in the U. S. National Museum.)

A triangular wood stringer capped with iron was used on the Great Western Railway when that road was relaid in 1857. The rail was held in place by bolts as shown in Fig. 68, made from a drawing in the

*Colburn & Holly, p. 92.

collection. As no splice bars save a thin plate to protect the wood at the end of the rail were used, this rail was expected to become popular, but its use was abandoned a few years afterwards.

Previous to 1850 English rails were usually rolled in lengths of 15, 16, and 18 feet; by 1855 the latter length became the universal standard.

As improved methods were adopted in iron manufacture, the length was increased in order to reduce the number of joints.* By 1857 rails were made at progressive mills 21 to 24 and 27 feet long and by 1860–'65 the 30-foot limit was reached.

Although longer lengths have been manufactured at a few mills, the 30-foot rail has been considered the standard for over a quarter of a century.

STEEL RAILS.

The first steel rails in Europe are said to have been rolled at the Ebbw Vale Works, in Wales, about 1855. The steel was produced by the Uchaturis process. Zerah Colburn states that "the quality of the steel is said to be equal to that used for razors."

The difficulty in obtaining good iron on this side of the water led the more prosperous American companies to continue to import steel and iron rails from abroad for some years.

Fig. 69 is a cross-section of the steel rails rolled at Dowlais, Wales, for the New Orleans, Memphis and Chattanooga Railroad in 1869, from a drawing in the collection.

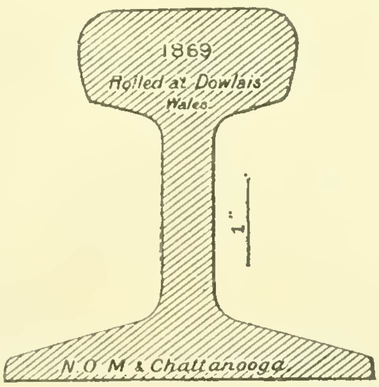


Fig. 69.
RAIL FOR NEW ORLEANS, MEMPHIS, AND CHATTANOOGA RAILROAD, ROLLED AT DOWLAIS, WALES, 1869.
(From a drawing in the U. S. National Museum.)

STEEL RAILS ROLLED IN AMERICA.

The introduction of Bessemer steel in America and the conflicts in the United States Patent Office, which finally resulted in a compromise and consolidation of the various interests involved, form a very interesting chapter in the history of American manufacture.

In Swank's "History of Iron in all Ages" I find that "the first steel rails ever made in this country were rolled at the North Chicago Rolling Mills in May, 1865." These were experimental rails, only a few

* In 1840 it was not uncommon to find eight hundred joints in a mile of single track. Now, 1890, the number is reduced to about three hundred and fifty.

being rolled in the presence of a committee of the American Iron and Steel Association.

The first steel rails ever rolled in the United States upon order in the way of regular business were rolled by the Cambria Iron Company, at Johnstown, Pennsylvania, in August, 1867. In no one year during the next five years were more than 40,000 tons of Bessemer steel rails manufactured in the United States.

About 1870–'73 attempts were made by several rail manufactures to roll rails that should have a steel head and iron web and flange—"steel top rail," it was called. A considerable quantity of this rail was rolled by the Trenton Iron Company for the New Jersey division of the Pennsylvania Railroad Company. While this experiment was reasonably successful the lessened cost of making steel, soon afterwards made it practicable to make the whole rail of steel.

The production of steel rails, which aggregated 90,000 tons in 1872, increased from year to year, so that in 1882, ten years later, the output reached nearly 1,500,000 tons, the price falling from $140 to $35, or one-quarter the cost of ten years before.

During the last ten or twelve years no radical change has been made in the shape of the section of rails laid by first-class railroads. It is true that the constantly increasing weight of the locomotive and of the lading of the freight cars has made it necessary to use heavier rails—the increased metal being put in the head, where the traffic is heavy, or in the base (the base of some standard sections being made as wide as 5 or 5½ inches), where the cross-ties upon which the rail is laid are of soft wood. The general shape of the rail has, however, been but slightly changed.

Sections of the standard rails laid by the Pennsylvania Railroad Company are shown in Figs. 70, 71, 72, 73, 74, 75, and by the Chicago, Burlington and Quincy Railroad Company* in Figs. 76, 77 78 79.

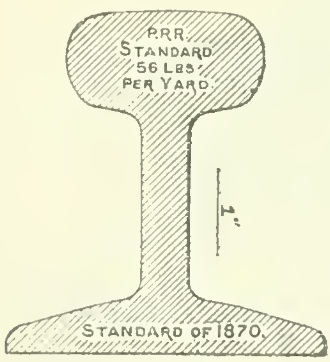


FIG. 70.

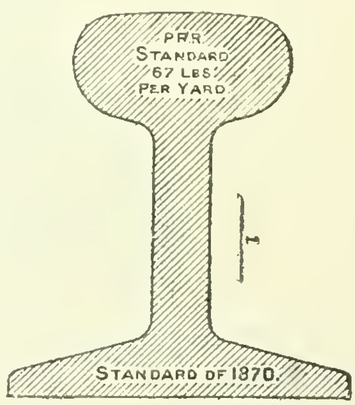
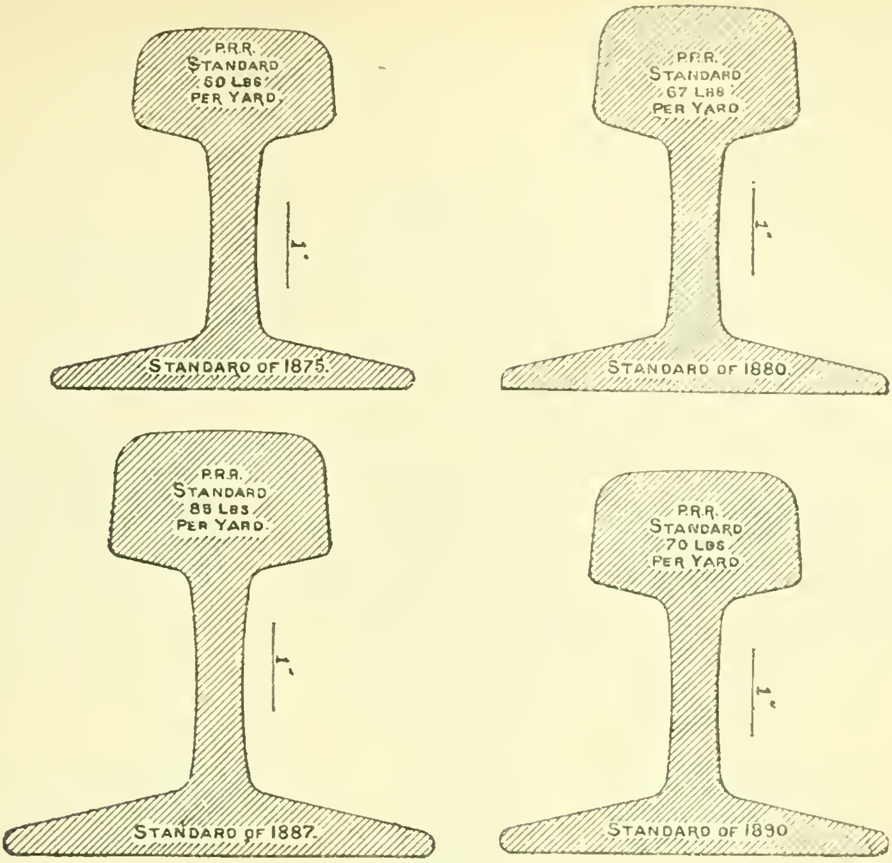


FIG. 71.

PENNSYLVANAIA RAILROAD STANDARD RAILS, 1870.

(From drawings in U. S. National Museum.)

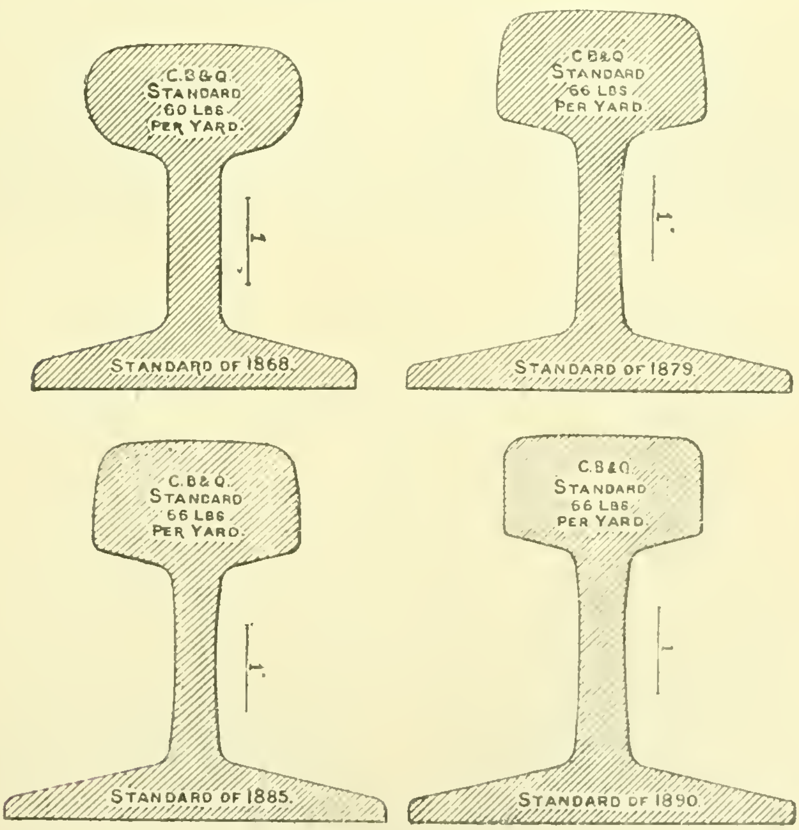
* For abstract of letter from Mr. F. A. Delanoe, second vice-president Chicago, Burlington and Quincy Railroad, giving interesting historical data regarding rails used on the Chicago, Burlington and Quincy Railroad, see below.



Figs. 72–75.

PENNSYLVANIA RAILROAD STANDARD RAILS, 1875, 1880, 1887, 1890.

(From drawings in the U. S. National Museum.)



Figs. 76–79.

STANDARD CHICAGO, BURLINGTON AND QUINCY RAILROAD COMPANY'S STANDARD RAILS, 1868, 1880, 1885, 1890.

(From chart furnished by Chicago, Burlington and Quincy Railroad.)

Figs. 80, 81, 82, 83, 84, 85, and 86 show sections of the rails manufactured during various years at the works of the Bethlehem Iron Com-

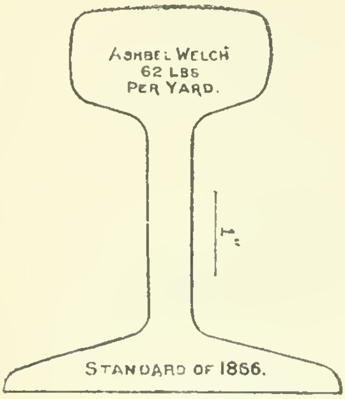


Fig. 80.

Rail Rolled by the Bethlehem Iron Company. Ashbel Welch Pattern, 62 pounds, 1866.

(From chart furnished by the Bethlehem Iron Company.)

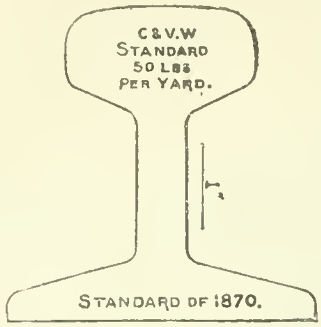


Fig. 81.

Rail Rolled by the Bethlehem Iron Company, C.V. and W. Railroad Pattern, 50 pounds, 1870.

(From chart furnished by the Bethlehem Iron Company.)

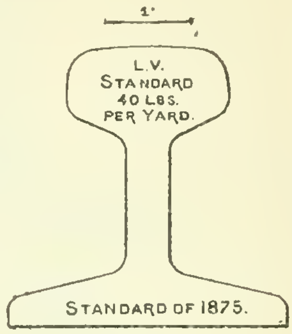


Fig. 82.

Rail rolled by the Bethlehem Iron Company, Lehigh Valley Railroad Pattern, 40 pounds, 1875.

(From chart furnished by the Bethlehem Iron Company.)

Fig. 83.

Rail Rolled by the Bethlehem Iron Company, St. Louis and Santa Fé Railroad Pattern, 52 pounds, 1879.

(From chart furnished by the Bethlehem Iron Company.)

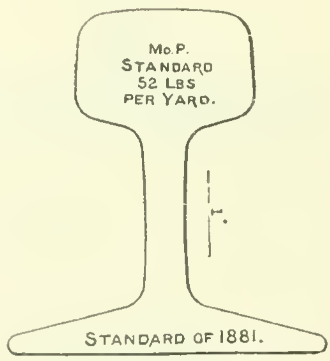


Fig. 84.

Rail Rolled by the Bethlehem Iron Company, Missouri Pacific Railroad Pattern, 52 pounds, 1881.

(From chart furnished by the Bethlehem Iron Company.)

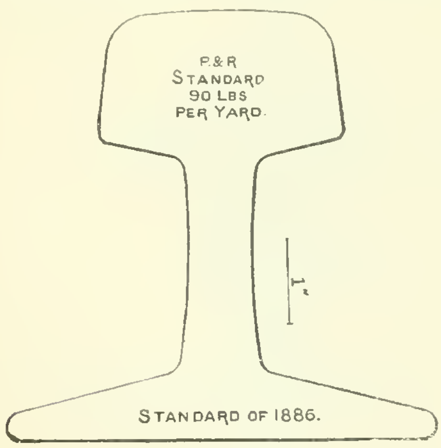


Fig. 85.

Rail Rolled by the Bethlehem Iron Company, Philadelphia and Reading Pattern, 90 pounds, 1886.

(From chart furnished by the Bethlehem Iron Company.)

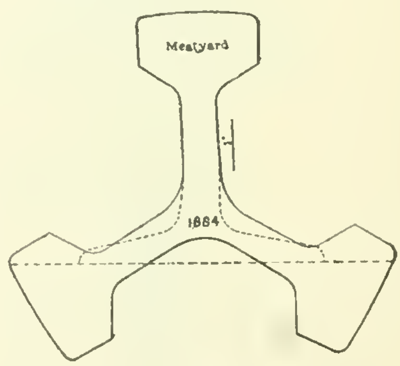


Fig. 86.

Rail Rolled by the Bethlehem Iron Company, "Meat-Yard Pattern," 1884.

(From chart furnished by the Bethlehem Iron Company.)

pany. The plates are made from drawings courteously furnished by the officials of this company.

Sections of rail rolled by the Phœnix Iron Works during the years 1855, 1856, and 1857 are illustrated under the paragraph devoted to splices. (See Figs. 115, 116, 117.)

THE STEVENS RAIL IN EUROPE.

About 1837 a rail with a base similar to the Stevens rail was designed by Charles Blacker Vignoles, an English railway engineer, and the names "Vignoles's rail" and "contractor's rail" have been applied to the various modifications of the Stevens rail, both in England and on the continent, since that time.

A section of the Stevens rail, $4\frac{1}{4}$ inches high, with a base 6 inches wide, in use on the Great Western Railway of England in 1858, is shown in Fig. 87, which is made from a drawing in the collection. This

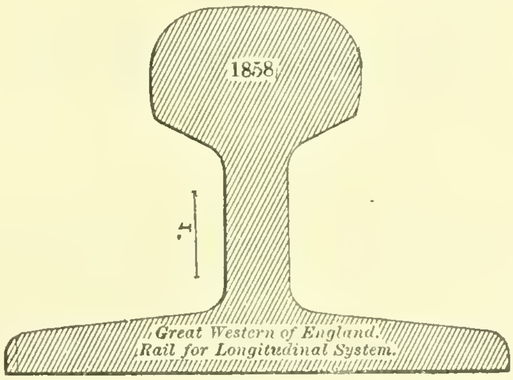


Fig. 87.
STEVENS RAIL LAID ON GREAT WESTERN RAILWAY, OF ENGLAND (LONGITUDINAL SYSTEM), 1858.
(From a drawing in the U. S. National Museum.)

rail was made with a wide base in order that it should have sufficient bearing on the stringer, to which it was attached by screw bolts. The Great Western was a broad-gauge railroad, the gauge being 7 feet.

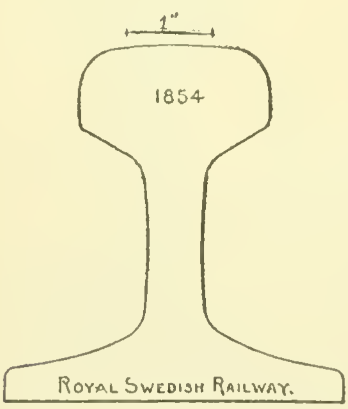


Fig. 88.
STEVENS RAIL ADOPTED BY THE ROYAL RAILWAY OF SWEDEN, 1854.
(From drawing in the U. S. National Museum.)

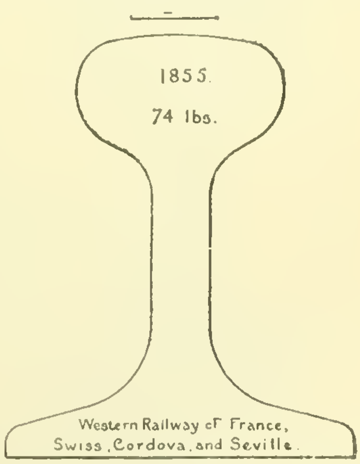


Fig. 89.
STEVENS RAIL IN USE ON THE WESTERN RAILWAY OF FRANCE, 1855.
[From drawing in the U. S. National Museum.]

The types of Stevens rail adopted by the Royal Swedish Railway in 1854 and by the Western Railway of France in 1855 are shown in Figs. 88 and 89, made from drawings in the collection.

A cross-section of the "rail Vignole," about $5\frac{7}{12}$ inches high, with a base $5\frac{1}{4}$ inches wide, in use on the Chemin de fer Du Nord, France, in 1888, is shown in Fig. 90, which is made from a drawing in the collection.

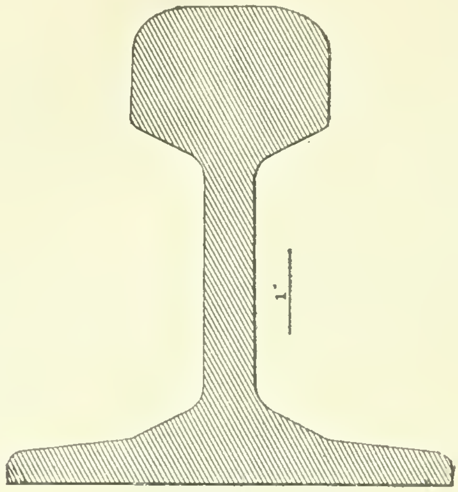


Fig. 90.
STEVENS RAIL, CHEMIN DE FER DU NORD, FRANCE, 1888. (CALLED THE VIGNOLE RAIL IN EUROPE).
From a drawing in the U. S. National Museum.

A cross-section of the standard rail adopted by the Belgian authorities for the government railroads, 1889, is shown in Fig. 91. This modification of the Stevens rail was designed by Mr. C. P. Sandberg, with

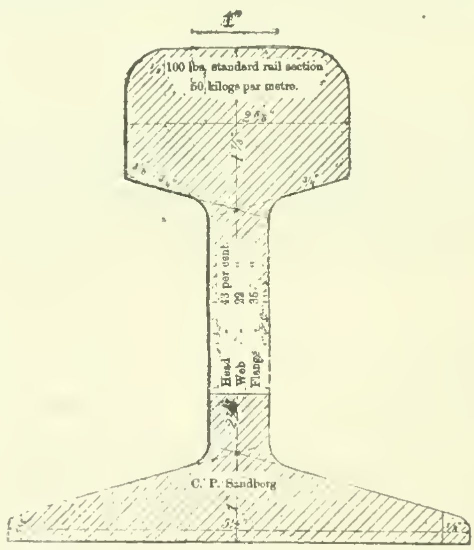


Fig. 91.
STANDARD RAIL OF BELGIAN GOVERNMENT RAILWAYS, 1889. SANDBERG SECTION
From a drawing in the U. S. National Museum.)

special reference to joint fixtures, cost and speed, and the lading of the trains which are to run over it. The rail is $5\frac{3}{4}$ inches high, with base $5\frac{1}{2}$ inches wide, and weighs about 100 pounds per yard.

THE "BULL-HEADED" RAIL.

The bull-headed rail was originally designed with a view to use first the top and, after the top had become worn, the bottom as a running surface, and in some cases as shown in the rail laid on the Strasbourg Railway in 1858, the top and bottom were rolled exactly alike. (See Fig. 92, made from the drawing in the collection.) But as it was found

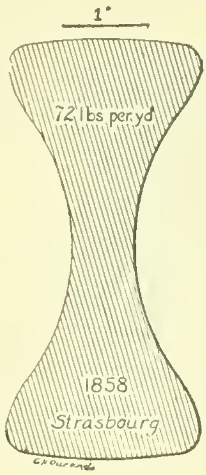


Fig. 92.
BULL-HEADED RAIL—STRASBOURG RAILWAY, 1858.
(From a drawing in the U. S. National Museum.)

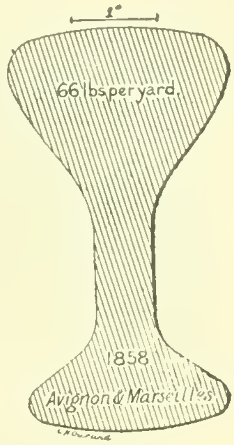


Fig. 93.
BULL-HEADED RAIL—AVIGNON AND MARSEILLES RAILWAY, 1858.
(From a drawing in the U. S. National Museum.)

that the wear of the rail in the chairs made the lower surface rough, this practice was abandoned, and a larger portion of the metal has since generally been put into the head to give increased wearing surface. A section of the rail designed with this end in view, and in use on the Avignon and Marseilles Railway in 1858, from a drawing in the collection, is shown in Fig. 93.

English railway managers continue to lay the "bull-headed" rail in chairs in a very similar manner to what was done fifty or sixty years ago.

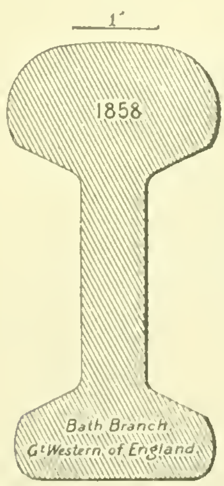


Fig. 94.
BULL-HEADED RAIL—BATH BRANCH GREAT WESTERN OF ENGLAND, 1858.
(From a drawing in the U. S. National Museum.)

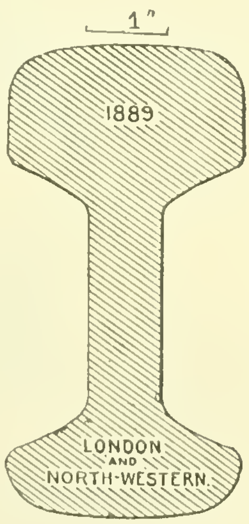


Fig. 95.
BULL-HEADED RAIL—LONDON AND NORTH-WESTERN RAILWAY, 1889.
(From original in the U. S National Museum.)

Cross-sections of the rail laid on the Great Western Railway in 1858 is shown in Fig. 94 (from a drawing in the collection), and a cross-section of the rail of the London and Northwestern Railway in 1889 is shown in Fig. 95 (from an original rail in the collection).

STRINGERS AND TIES OF WOOD.

The high price of iron led the engineers of many early roads, built upon a small capitalization to design a superstructure composed mainly of wood, as little iron as possible being used. The wooden rail, capped with strap-iron, previously alluded to, was attached to longitudinal stringers, and these were kept "in line" by cross timbers 4, 5, and sometimes 6 feet apart.

On roads laid with English T-rails in chairs, or with the Stevens rail spiked to the support, the necessity for a longitudinal support for the rail did not exist, and the stringer being dispensed with, it became necessary to put the cross-ties closer together.

Ties have been used from time to time of various widths, lengths, and thicknesses, split, sawed, and hewn, as illustrated in Figs. 96, 97, and 98.

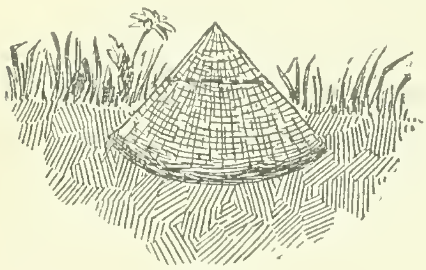


Fig. 96.
Cross-tie—Split quarter Log.

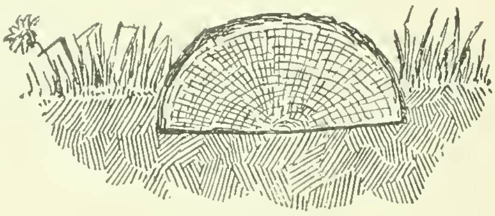


Fig. 97.
Cross-tie—Split half Log.

The specifications for cross-ties now require that they be hewn on both sides, as shown in Fig. 98, and that they be cut to exact lengths, 96 or 102 inches.

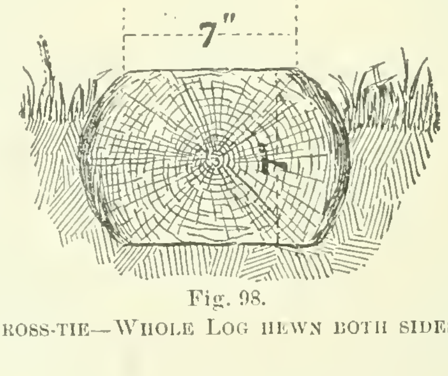


Fig. 98.
Cross-tie—Whole Log hewn both sides.

METAL TIES.

The extensive use of metal ties in foreign countries has led a few American managers to put down a limited number of experimental iron ties on their roads. About two thousand iron ties of the standard adopted by the London and Northwestern Railway of England, were placed in the tracks of the Pennsylvania Railroad Company about a year ago. Fig. 99 illustrates a steel cross-tie* with rail fastenings, in

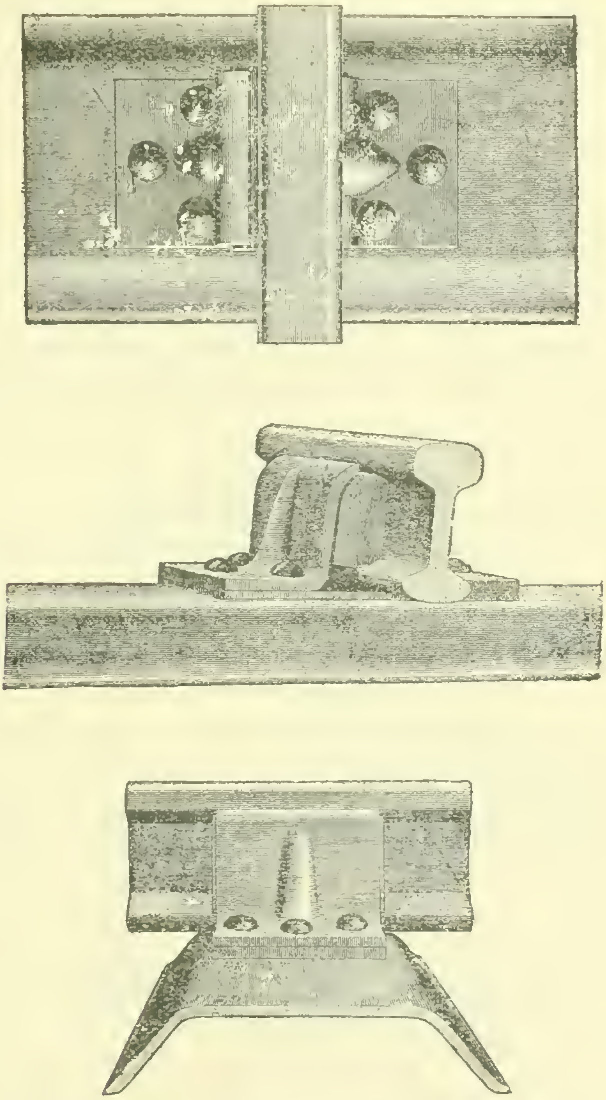


Fig. 99.
STEEL TIE AND PERMANENT WAY, LONDON AND NORTHWESTERN RAILWAY, 1885.
(From original in the U. S. National Museum.)

the collection. It is the opinion of the chief engineer of the Pennsylvania Railroad that the iron tie will not be extensively used in America as long as white-oak standard cross-ties can be purchased for $1 or less.†

An exhaustive report upon the iron cross-ties used by European railways, compiled by Russel E. E. Tratman, of the Engineering News, will be found in the report of B. E. Fernow, chief of the Division of Forestry, in Bulletin No. 3 of the U. S. Agricultural Department.

* Presented to the U. S. National Museum by Mr. F. W. Webb, general locomotive superintendent London and Northwestern Railway, Crewe, England. Compare Plate III (opposite page 124). Report of the U. S. National Museum for 1886.

† Seventy cents is the price paid for a white oak cross-tie 7 by 7 inches, 8½ feet long, by the Pennsylvania Railroad in 1890.

METAL TRACK IN ENGLAND AND HER COLONIES.

Fig. 100 illustrates the steel cross-tie, riveted chair and wedge in use on the London and Northwestern Railway in 1889. Steel wedges as well as wedges of wood are used to keep the "bull-headed" rail in place.

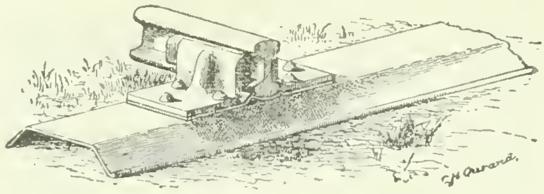


Fig. 100.
METAL TRACK, LONDON AND NORTHWESTERN RAILWAY OF ENGLAND, 1889.
(From a drawing in the U. S. National Museum.)

The iron cross-tie on the Midland Railway is somewhat similar to that used on the London and Northwestern (see Fig. 101). The chair, however,

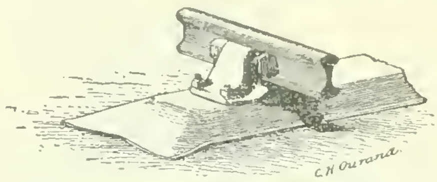


Fig. 101.
METAL TRACK, MIDLAND RAILWAY OF ENGLAND, 1889.
(From a drawing in the U. S. National Museum.)

is attached to the cross-tie by bolts and nuts, instead of by rivets as in the former system. The ends of the ties on the outer sides of the double tracks are generally depressed as shown. Between the tracks the ends are left open, so that the ballast may be properly tamped.

Fig. 102.
METAL TRACK, NORMANTON LINE, (QUEENSLAND, 1889.
(From a drawing in the U. S. National Museum.)

Iron cross-ties are also used on the Normanton line, Queensland, see Fig. 102, the rail being held in position by an adjustable clip, on the inside of the base, with nut and screw arranged so that slight corrections in the gauge can be made when necessary.

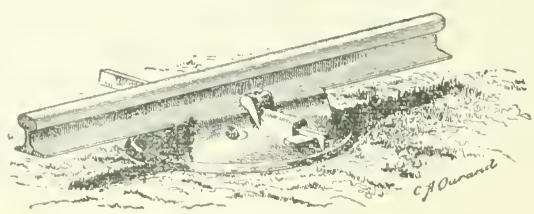


Fig. 103.
METAL "POT" TIE SYSTEM, MIDLAND RAILWAY OF INDIA, 1889.
(From a drawing in the U. S. National Museum.)

On the Indian Midland Railway the cast "pot" tie has been used with favorable results. See Fig. 103. The gauge is maintained by iron rods extending across the track and held in position by wedges driven into a slot in the end of each tie bar.

HOLLAND, GERMANY AND BELGIUM.

The "Post" tie, see Fig. 104, has been used extensively on the continent of Europe. The section varies in depth and width at the center,

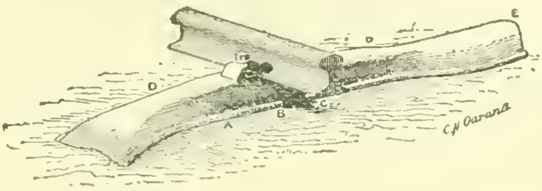


Fig. 104.
METAL TRACK, HOLLAND "POST" TIE, 1889.
(From a drawing in the U. S. National Museum.)

quarter, and ends; being the deepest in the center, an admirable opportunity is given for ballasting. The rail is held to the tie by an adjustable clip fastened by bolt and nut.

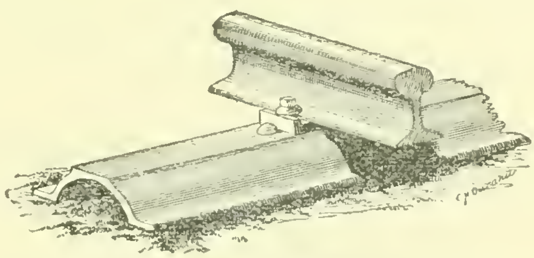


Fig. 105.
METAL TRACK, GREAT CENTRAL RAILWAY OF BELGIUM, 1889.
(From a drawing in the U. S. National Museum.)

The iron ties used on the Great Central Railway of Belgium (see Fig. 105), are also made narrow in the middle, and the rail on this tie is fastened with a screw bolt, the head of which has a direct hold on the base of the rail.

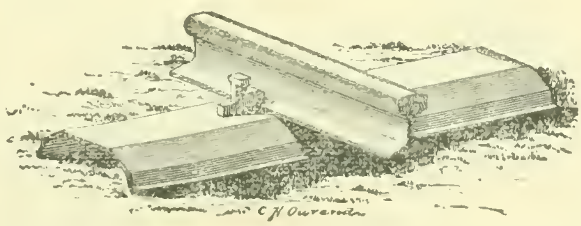


Fig. 106.
BERGH AND MARCHE METAL TRACK SYSTEM, ELBERFELD RAILWAY, GERMANY, 1889.
(From a drawing in the U. S. National Museum.)

The Bergh and Marche system is used on the Elberfeld Railway, of Germany. The fingered fastening slides over the base of the rail, holding it to the tie. See Fig. 106.

On the Right-Bank-of-the-Rhine Railway, the Haarman longitudinal system is now in use (See Fig. 107). Iron cross-ties are first imbedded

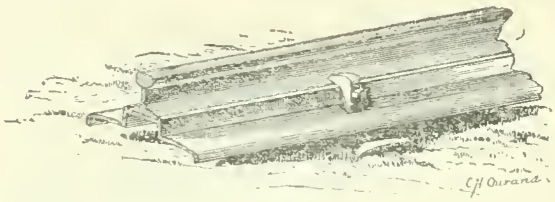


Fig. 107.
HAARMAN LONGITUDINAL METAL TRACK, RIGHT-BANK-OF-THE-RHINE RAILWAY, 1889.
(From a drawing in the U. S. National Museum.)

in the ground, and to these the longitudinal iron sleepers are fastened. The base of the rail is held in place by a very complicated system of fastening.

FRANCE, EGYPT, SPAIN, ETC.

The Vautherin tie, which is used on several French railways, is very similar in shape to that used on the Midland Railway, of England, the chair being attached to the tie by bolt and nut. See Fig. 108.

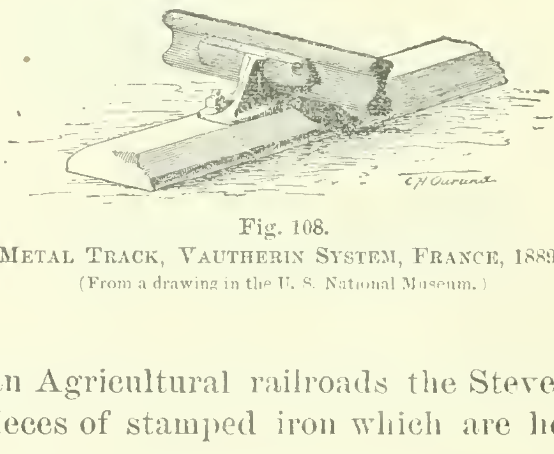


Fig. 108.
METAL TRACK, VAUTHERIN SYSTEM, FRANCE, 1889.
(From a drawing in the U. S. National Museum.)

On the Egyptian Agricultural railroads the Stevens rail is laid on a series of short pieces of stamped iron which are held in place by tie-

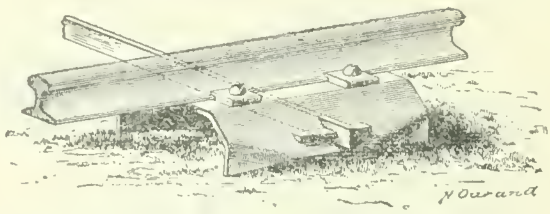


Fig. 109.
METAL TRACK, EGYPTIAN AGRICULTURAL RAILWAY, 1889.
(From a drawing in the U. S. National Museum.)

rods. This system is in use through portions of Egypt where the traffic and character of the soil make it possible to use this system, which is similar to the "pot" tie system in India. See Fig. 109.

On the Bilbao and Las Arenas Railway, of Spain, a system (see Fig. 110) is in use similar to the "Post" system as far as the fastenings are

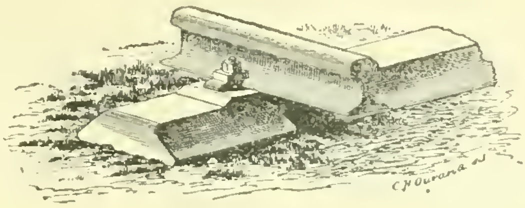


Fig. 110.
METAL TRACK, BILBAO AND LAS ARENAS, SPAIN, 1889.
(From a drawing in the U. S. National Museum.)

concerned. The cross section of the tie does not vary, however, either in depth or width.

The bull-head rail is laid on "pot" ties on portions of the Central Railway of the Argentine Republic. This system requires the use of

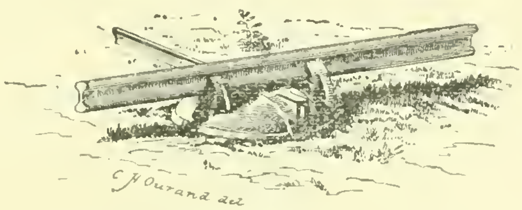


Fig. 111.
METAL TRACK, CENTRAL RAILWAY, ARGENTINE REPUBLIC, 1889.
(From a drawing in the U. S. National Museum.)

the chair with wedge fastening, (see Fig. 111). The rails are held to gauge by iron tie-rods.

JOINT FIXTURES.

Failure of the rail at the joint has from the beginning of railway construction directed thought towards the invention of the ideal fixture "as strong at the joint as at any part of the rail," an ideal which, after sixty years of experiment, has not yet been attained.

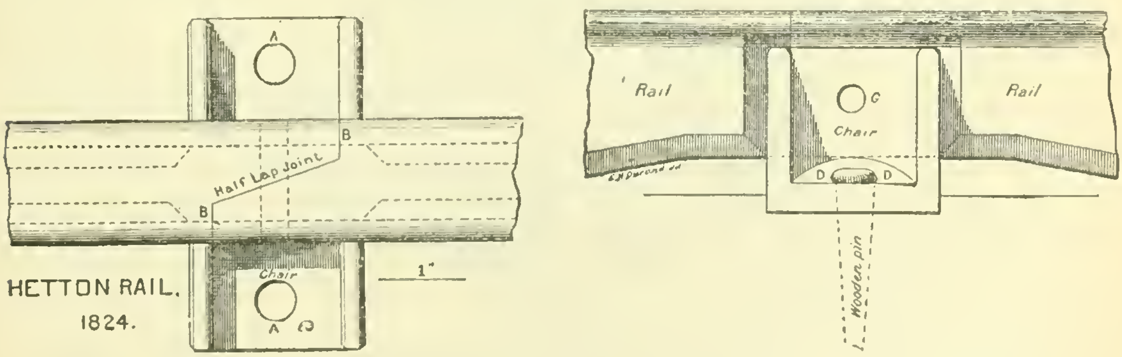
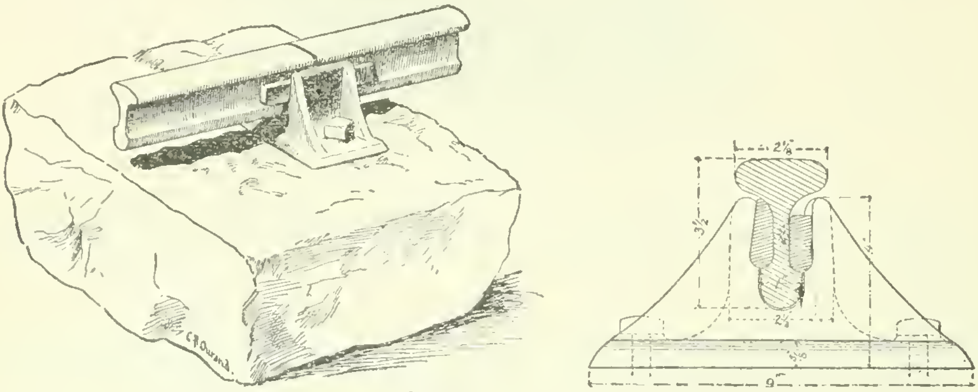


Fig. 112.
HALF-LAP JOINT, HETTON RAIL, 1824.
(From a drawing in the U. S. National Museum.)

The miter or "half lap joint" was used on the Hetton Colliery road in England in 1824. Fig. 112 is from a drawing in the collection.

The wooden pin shown secured the chair to a short wooden pile driven into the ground. The rails were 4 feet long. The joint fixtures in the tracks laid with various types of T-rails* were chairs slightly longer than those in the quarters and middle of the rail, and the ends of the rail were held in place by wedges, as shown in Figs. 113 and 113*a*. The



Figs. 113, 113*a*.
JOINT CHAIR AND WEDGE, OLD PORTAGE RAILROAD, 1832.
(From original in the U. S. National Museum.)

drawing is made from one of the original stone blocks from the old Portage Railroad in Pennsylvania, 1832, with rail and chair complete, which is in the collection. The rails, chairs, and joint fixtures for that railroad were manufactured in England in 1830.

THE BEGINNINGS OF THE SPLICE BAR.

The splice-bar or fish-plate was of necessity an American invention, since the Camden and Amboy Railroad, which was the first iron railway laid without chairs, found it necessary to use it. In Robert L. Stevens's original specifications, each rail was to have a projection on the stem at one end, which was intended to be riveted to the stem of the adjoining rail. Owing to impracticability of manufacture this plan was never

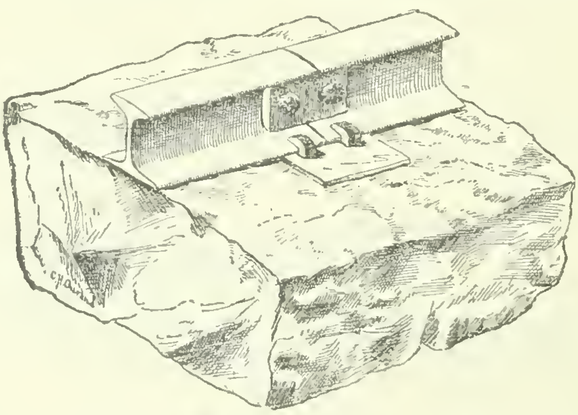


Fig. 114.
STONE BLOCK, RAIL, AND JOINT TONGUE LAID ON CAMDEN AND AMBOY RAILROAD IN 1831.
(From original specimen in the U. S. National Museum.)

carried out, and joint tongues (an illustration of which is to be found in the Report U. S. National Museum for 1886, Figs. 1 and 2, Plate II, opposite page 122) were used. These iron tongues were attached to the stems of the rail with hot rivets. Fig. 114 is from a drawing made from

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* T-rails were first rolled in lengths of 8, 12, and 16 feet.

an original stone block, rails, and joint fixtures, which were laid on the Camden and Amboy Railroad in 1830 and taken out of the track when the road was relaid with cross-ties a few years later.*

As will be seen by reference to Fig. 40 † the Camden and Amboy Railroad Company used the fish plate with screw-bolt and nut previous to 1837. This practice does not appear to have been pursued in England until ten years later. It is stated that "the fish joint (with bolts through the stem of the rail) was designed by W. Bridges Adams, 1847, and has been applied throughout the London and Northwestern Railway."‡

Rolled fish-plates 18 inches in length came into general use about 1850–'55. In 1858 those on the North London Railway of England were 27 inches long. Figs. 115, 116, and 117 are from drawings of the rails

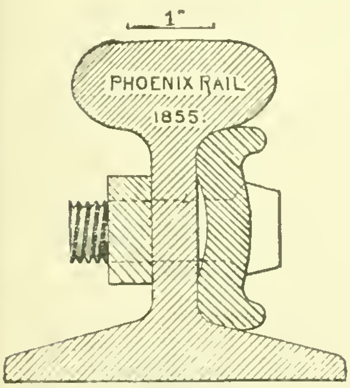

Fig. 115.
SINGLE SPLICE BAR FOR RAIL, ROLLED BY THE PHŒNIX IRON COMPANY, 1855.
(From chart furnished by the Phœnix Iron Company.)

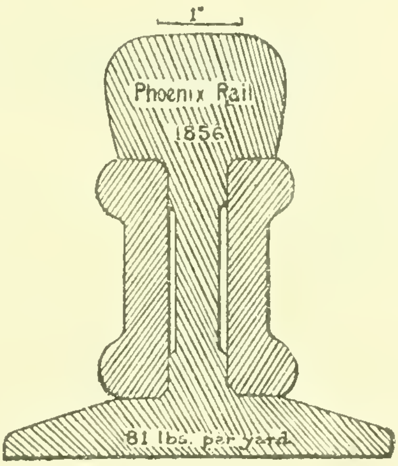

Fig. 116.
DOUBLE SPLICE BAR FOR RAIL, ROLLED BY THE PHŒNIX IRON COMPANY, 1856.
(From chart furnished by the Phœnix Iron Company.)

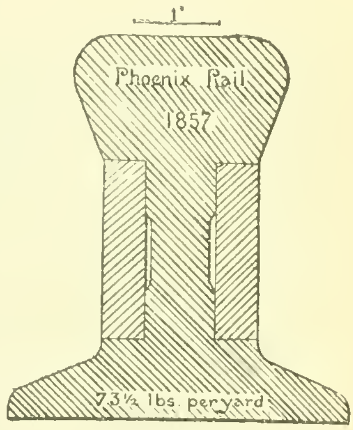

Fig. 117.
DOUBLE SPLICE BAR FOR RAIL, ROLLED BY THE PHŒNIX IRON COMPANY, 1857.
(From chart furnished by the Phœnix Iron Company.)

and splice-bars manufactured by the Phœnix Iron Company, of Phœnixville, Pa., previous to 1857. The figures are made from a chart § which the company had prepared in that year to show the many shapes of iron they were prepared to roll.

*On some roads the ends of the rails were simply spiked to the stone block or wooden stringer, and no attempt was made to fasten the rails to each other.

† From Stevenson's Engineering in North America, 1837.

‡ The Permanent Way of European Railways, Colburn & Holley, N. Y., 1858.

§ This chart, the only one in existence, was forwarded by the Phœnix Iron Company to Washington for inspection. For this courtesy the curator is indebted.

Fig. 118 shows the standard splice bar adopted by the Pennsylvania Railroad in 1870.

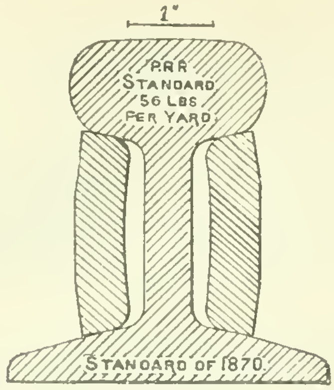

Fig. 118.
PLAIN SPLICE BAR, PENNSYLVANIA RAILROAD, 1870.
(From a drawing in the U. S. National Museum.)

WOODEN BLOCK JOINTS.

The cost of the iron joint fixtures led to experiments with wood blocks as early as 1840. Many roads that had used nothing but spikes and iron tie plates at the joints, added materially to the strength of these joints by drilling the stem of the rail, and bolting a block of wood of the proper shape to the outer side of the rail. About 1860, some of the Eastern roads adopted a standard joint fixture composed of a wooden block 48 inches long for the outside of the rail and a short iron splice bar to fit closely against the stem on the inside. Fig. 119 is

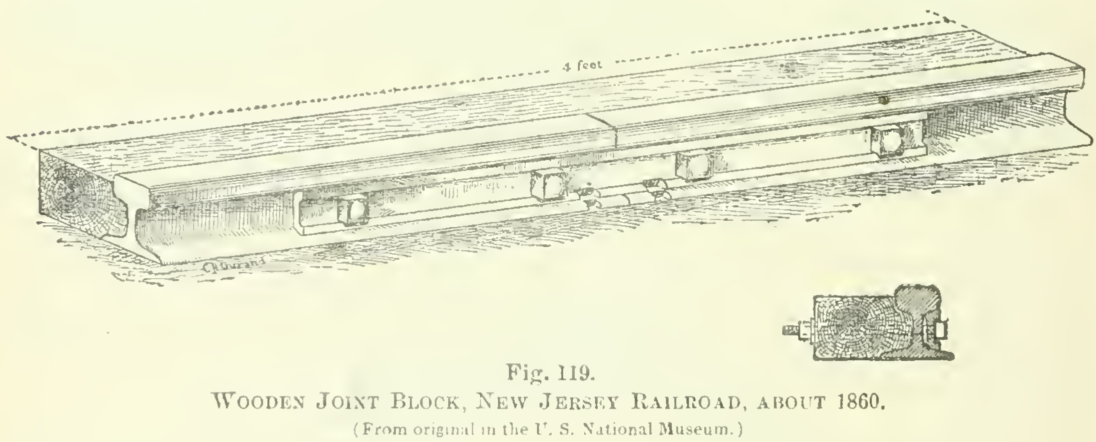

Fig. 119.
WOODEN JOINT BLOCK, NEW JERSEY RAILROAD, ABOUT 1860.
(From original in the U. S. National Museum.)

drawn from a set of the original joint fixtures that had been in the tracks of the present New York Division of the Pennsylvania Railroad for many years.* Many of these blocks were used with steel rails and made excellent track, when kept in proper repair.

SLOT RAIL AND RING JOINT.

About 1850, on some parts of the Camden and Amboy and West Jersey Railroads, the ring joint was used. A slot about 2 inches long was cut in the stem of each rail at both ends; into these slots a ring was

* Presented to the National Museum by Mr. James R. Smith, supervisor New York Division Pennsylvania Railroad, Newark, N. J.

slipped which encircled the base, to which it was secured by a wedge driven on each side of the stem between the ring and the base of the rail.

Fig. 120 is drawn from a ring joint and wedges which were in the track of the West Jersey Railroad for many years.*

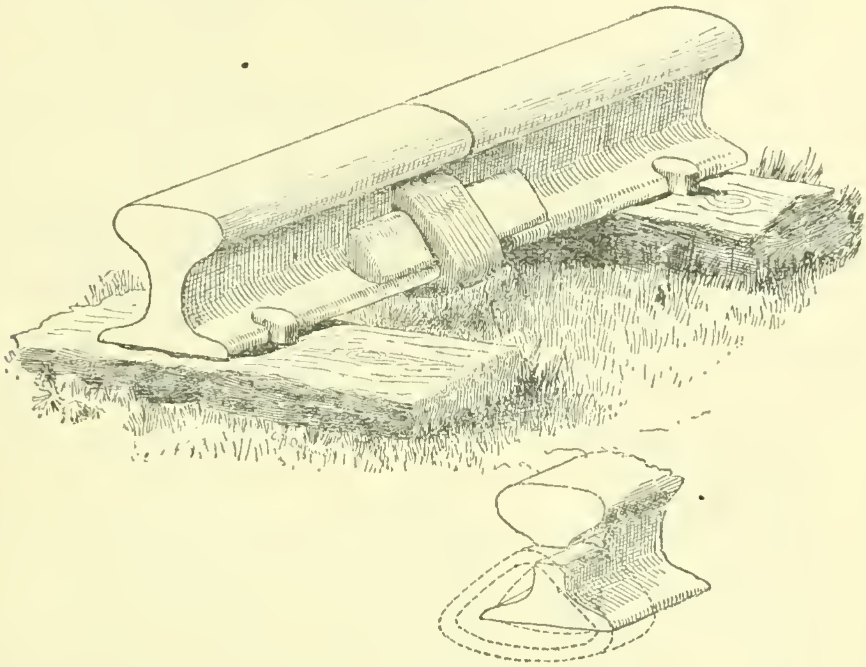

Fig. 120.
RING, JOINT, AND WEDGE USED ON THE WEST JERSEY RAILROAD.
(From original in the U. S. National Museum.)

About 1850, G. Samuels patented the method of scarfing the rail-heads and bending the ends of the rail so that the stems could be riveted together in the same way that boiler plates are put together, but this invention was not put into practice.

THE ANGLE SPLICE BAR.

As early as 1857 the angle splice bar (or cast-iron bracket joint, as it was then called) was tried on the Erie Railroad. The form of this splice-bar has been already illustrated in Fig. 52. It was abandoned after a short trial.

The wrought-iron angle splice-bar, somewhat similar in section to the Adams cast bracket joint, seems to have come into use about 1868.

*Presented to the Museum by Mr. W. McAllister, master mechanic of the Pennsylvania Railroad, at Camden, N. J.

Figs. 121, 122, 123, and 124* show the variations in form of the angle bar on the Pennsylvania Railroad, 1875, 1880, and 1890.

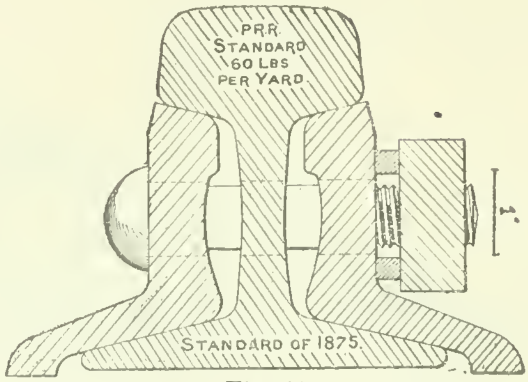

Fig. 121.

ANGLE SPLICE BAR, PENNSYLVANIA RAILROAD, 1875.

(From a drawing in the U. S. National Museum.)

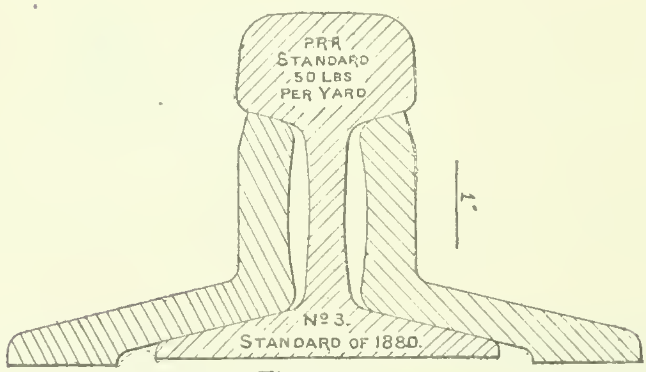

Fig. 122.

ANGLE SPLICE BAR, PENNSYLVANIA RAILROAD—50-LB. RAIL, 1880.

(From a drawing in the U. S. National Museum.)

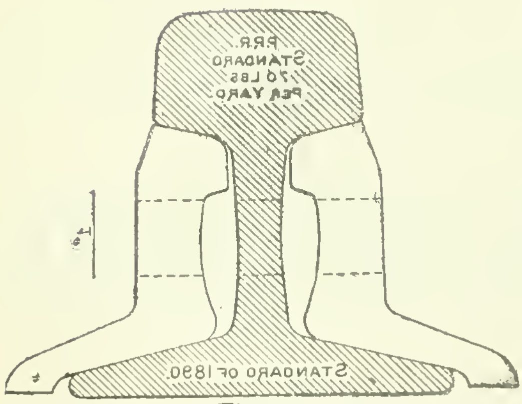

Fig. 123.

ANGLE SPLICE BAR, PENNSYLVANIA RAILROAD, STANDARD FOR 70-LB. RAIL, 1890.

(From a drawing in the U. S. National Museum.)

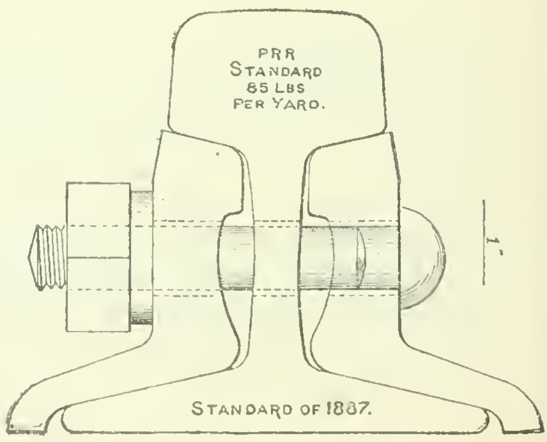

Fig. 124.

ANGLE SPLICE BAR, PENNSYLVANIA RAILROAD, STANDARD for 85-LB. RAIL, 1890.

(From a drawing in the U. S. National Museum.)

* These plates are from drawings in the collection deposited by Mr. Joseph T. Richards, assistant chief engineer of the Pennsylvania Railroad.

Figs. 125, 126, 127, and 128* show the various standards of angle splice-bars adopted by the Chicago, Burlington and Quincy Railroad, 1868, 1879, 1885, and 1890.

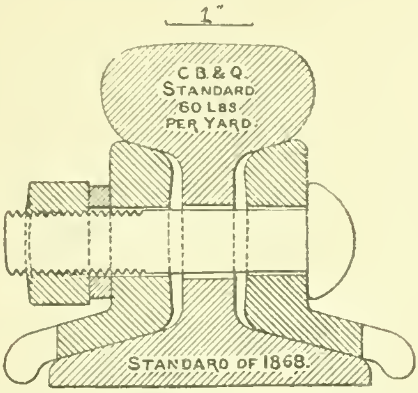

Fig. 125.

ANGLE SPLICE BAR, CHICAGO, BURLINGTON AND QUINCY RAILROAD, 60-LB. RAIL, 1868.

(From a drawing in the U. S. National Museum.)

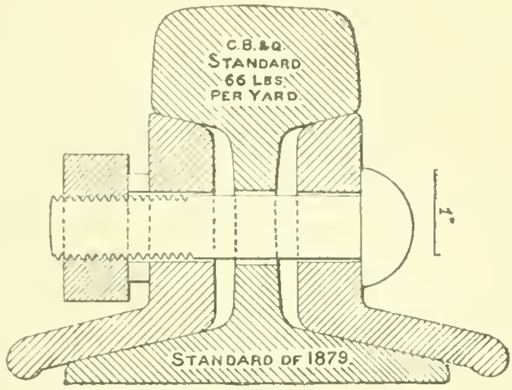

Fig. 126.

ANGLE SPLICE BAR, CHICAGO, BURLINGTON AND QUINCY RAILROAD, 66-LB. RAIL, 1879.

(From a drawing in the U. S. National Museum.)

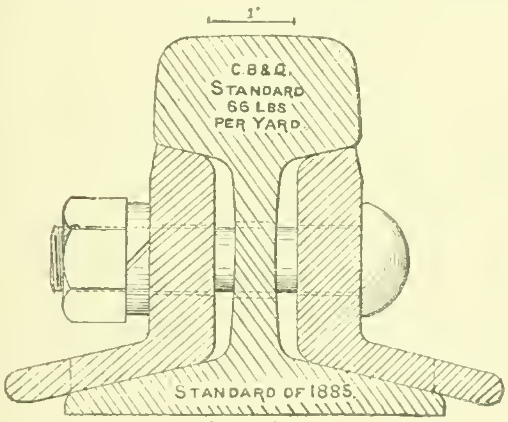

Fig. 127.

ANGLE SPLICE BAR, CHICAGO, BURLINGTON AND QUINCY RAILROAD, 66-LB. RAIL, 1885.

(From a drawing in the U. S. National Museum.)

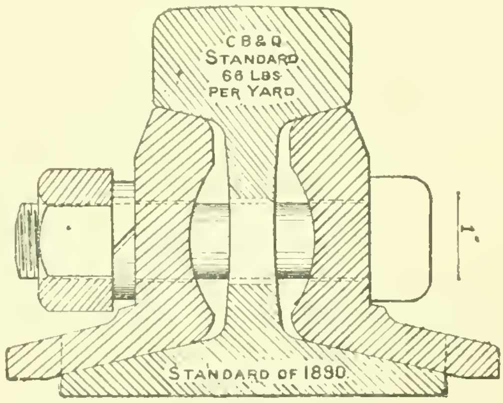

Fig. 128.

ANGLE SPLICE BAR, CHICAGO, BURLINGTON AND QUINCY RAILROAD, 66-LB. RAIL, 1890.

(From a drawing in the U. S. National Museum.)

Mr. F. A. Delano, second vice-president of the Chicago, Burlington and Quincy Railroad, in charge of the bureau of rail and joint inspection of that company, has compiled the following data concerning the rails and joint fixtures on that road during various years, and has communicated the same to the curator by letter, from which the following abstracts have been taken:

CHICAGO, BURLINGTON AND QUINCY RAILROAD COMPANY,
SECOND VICE PRESIDENT'S OFFICE,
BUREAU OF RAIL AND JOINT RAIL INSPECTION, TESTS, AND RECORDS,
Chicago, *June* 19, 1890.

DEAR SIR: Regarding your request for standard rails in use on the Chicago, Burlington and Quincy in 1870, 1880, and 1890, I take the liberty of going further back than the dates you mention. in order to illustrate more fully the development of track, and show, if possible, what the tendency has been.

When the Chicago, Burlington and Quincy Railroad was first organized in 1854,

* These plates are from drawings in the collection deposited by Mr. F. A. Delano, second vice-president of the Chicago, Burlington and Quincy Railroad.

with 58 miles of railroad, the track was laid with compound or continuous iron rail riveted together. I have not a drawing of this rail, but you are doubtless familiar with the design. The rail was rudely similar to the present T rail divided in half vertically through the web, and these two halves riveted together broken jointed, so that the end of one half rail did not come at the end of another half rail. This made an excellent track for the time being, as the reports show, and indeed it was a very expensive track, for the rail weighed some 72 pounds per yard and cost some $70 to $75 per ton. This compound rail, however, soon began to show its defects, which I need hardly explain here, and some two years later, when the Chicago, Burlington and Quincy by consolidation with the Central Military Tract Railroad became an important road with 138 miles of track, the T rail was adopted as standard and laid with cast-iron chairs at the joints. Wrought-iron chairs I find were also used to a limited extent at this time.

In 1862 the construction of the road from Aurora to Chicago, a distance of 35 miles, was begun, and for this purpose 3,500 tons of "the best quality iron rail were purchased of the Cambria Iron Company, of Pennsylvania, at a price of $65 per ton delivered at Chicago."

The chief engineer, in his report for that year, says that the compound rail was being removed from track as rapidly as possible, and being replaced with new and rerolled iron T rails of the ordinary pattern. These T rails had a maximum length of 21 feet.

In 1864 the general use of fish-plates, a flat piece of iron fitting close to the web of the rail between the head and the base, was adopted. The chief engineer in his report for that year says "the fish-joint splices make a smoother track, less liable to get out of repair, and cost less than the ordinary rubber chair." This allusion to the "rubber chair" rather puzzles me. I do not understand whether a piece of rubber was introduced into the bottom of the ordinary cast-iron chair to obviate the trouble from noise and stop the rattling, or not; but I presume that this was the case. At this time quite a large proportion of the rail laid in each year was rerolled iron rail, and I find that the cost of rerolling amounted to over $35 per ton at Chicago, and a good deal more than that in 1865 and 1866, on account of the high prices for labor and material following the war period.

In the summer of 1867, 3 miles of experimental steel rails were laid in different places in Illinois where they would receive very severe service. I can not learn the exact section or weight per yard of this rail; but, from what I can learn, I imagine that the rail weighed between 56 and 60 pounds per yard, and was very similar in design to the old 60-pound rail, shown in print No. 1, which I send you. This rail was laid with fish-plates similar to the then recent practice with iron rails, and as in the case of iron rails, it was laid with "supported" or "on-tie" joints, the ends of the rails being notched to admit of spiking at that point and prevent the rail from creeping. The first experience with this rail was not altogether favorable. Of 3 miles of track laid, seven rails broke in the first year; in each case, however, the chief engineer tells us, where the holes in the splice bars had been punched instead of drilled. In the next two years, however, there were no breakages and in 1870 it was decided to adopt steel as standard for main track renewals or new construction. During the year 72 miles of steel rails were laid, which with the 6 miles already in track made 78 miles of steel rail out of 302 miles then in operation. The road then consisted of a line from Chicago to East Burlington and from Galesburg to Quincy. The steel rail then used was substantially the rail shown in blue print No. 1, which I send you, with a plain fish-plate and not the angle-bar, which was adopted in later years.

In 1875 or 1876 an angle-bar was adopted for this rail, and this was slightly modified in 1879. This provided for a "supported" or "on-tie" joint. The only difficulty with it was that the slot near the center of the angle bar was frequent cause for breakage at that point. In 1879, therefore, the 66-pound rail for a suspended joint was designed and made the standard.

In 1880 the length of the road in operation was 2,653 miles in Illinois, Iowa, and Nebraska. Of this mileage, 1,100 miles were steel rails.

When the 60-pound rail was discarded as a standard in 1879, two sections of steel rail were adopted of a substantially similar design and weighing 56 and 66 pounds per yard, respectively, for lines of light and heavy traffic. The joint used on the 66-pound rail is already mentioned, and the joint on the 56-pound rail provides for a "supported" or "on-tie" joint, the idea being that with a stronger or heavier rail a suspended joint could be used, where it would not be a good thing for a weaker rail. Both these rails continued to be used almost up to the present date. During this period considerable dissatisfaction was found with the angle bar for the 56-pound rail, which, on account of its slot in the center, frequently broke. To obviate this difficulty, without seriously adding to the cost of the rail, I lengthened the angle bar at one end for this rail and the old 60-pound rail 5½ inches, thus allowing the slot at the joint to be omitted, and yet preserving the on-tie or supported joint. This was adopted as standard early in 1889. During this period also considerable dissatisfaction was found with the suspended joint on the 66-pound rail, and in the latter part of 1889 the angle bar was lengthened 6 inches, so as to allow a three-tie supported joint, the same cross-section of angle bar, however, being used.

Quite recently, in the year of 1890, the old 66-pound section of rail has been superseded by a new standard, namely, the Northern Pacific 66-pound rail, with the angle bar. The notable difference between this rail and the other 66-pound rail lies in the fact that the distribution of metal in the different parts of the rail is more equal. The rail itself is stiffer and higher, and the angle bar very much stiffer. These differences have been made chiefly by putting considerable less metal in the head of the rail, because we have found in practice that a very small portion of the head wears away, and that the rail is usually removed from track for other causes.

You will note particularly what an advance has been made in perfecting the joint. After trying the suspended joint, we returned again to the supported joint, at the same time making the angle bar much stiffer, bringing the bolt-holes closer to the end, and using seven-eighths instead of three fourths bolts.

In the mean time the Chicago, Burlington and Quincy Railroad is experimenting with a view of adopting for lines of the heaviest traffic a heavier rail. In 1888 two sections of 85-pound rail were designed, and 7½ miles of each section were rolled and laid in track side by side in 1889. In 1890 a similar amount of each section has again been rolled and laid in track. It is impossible at present to determine which rail is likely to give the best satisfaction, but we hope before spring to get some light on the subject. Besides the test in track which is being made of these two sections of 85-pound rail, quite elaborate tests of each section were made about a year ago at the United States Government Watertown Arsenal, the results of which I dare say you have seen.

In the mean time, while we are debating what shall be the design and weight of our rail for the lines of the heaviest traffic, it is a settled fact that we shall not again buy for standard-gauge railroad any rail lighter than 66 pounds per yard. The Chicago, Burlington and Quincy, owning and controlling as it does upwards of 7,000 miles of railroad, always has large quantities of rail not sufficiently good for main track use, but which either with or without the sawing off of the ends is perfectly good for branch-line service, so that our lines with very light traffic will usually be laid either with the light rail which was originally put there or with second hand rail removed from main line.

Hoping that I have given you the information you desired, I have the honor to remain, yours, truly,

FRED. A. DELANO.

Mr. J. E. WATKINS,

Curator, U. S. National Museum, Washington, D. C.

RAILS ROLLED BY THE BETHLEHEM IRON COMPANY.

Fig. 129 is from a drawing presented to the collection by the Bethlehem Iron Company through the courtesy of Mr. E. M. McIlvain to show the standard joint fixture of the Lehigh Valley Railroad, 1890.

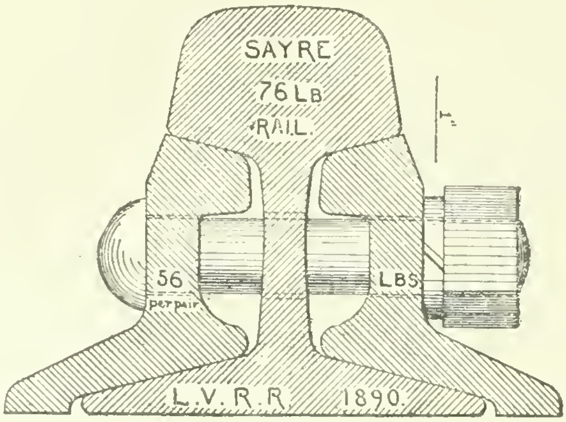

Fig. 129.
DOUBLE ANGLE SAYRE-FRITZ SPLICE BAR, LEHIGH VALLEY RAILROAD, 1890.
(From a drawing in the U. S. National Museum.)

The rail is of the Sayre pattern, and the splices are of the Sayre-Fritz standard.

LETTER FROM THE BETHLEHEM IRON COMPANY.

SOUTH BETHLEHEM, PA., *June* 30, 1890.

SIR: The first rails rolled by us were iron rails, and owing to our early record books having become mislaid, we are at a loss as to what to send you to be of any use. We inclose, however, under separate cover, a number of blue prints, that we trust you may be able to use to advantage.

You will note that a great many of the sections on the blue prints are marked unknown. Records relating to these sections have been lost or mislaid. Where we were able to do so, the year the rail was rolled the section and name of the road using the rail has been noted on the blue prints.

We also send you a blue print of a compound rail, which, however, we never attempted to make, the scheme not having originated with us. You will also find inclosed several sections designed by Mr. Robt. H. Sayre, with Sayre-Fritz splice plates.

Respectfully,

THE BETHLEHEM IRON CONPANY,
E. M. MCILVAIN,
Assistant to Vice-President.

J. E. WATKINS,
U. S. National Museum, Washington, D. C.

Several types of joint fixtures designed to support the base of the rail have been designed from time to time. Fig. 130 shows a joint of this type which was in use on a western railroad in 1869. Fig. 131 illustrates the Fisher and Norris joint as improved by Mr. Clark Fisher in 1888, in which the base of the rail is made to take much of the strain at the joint.

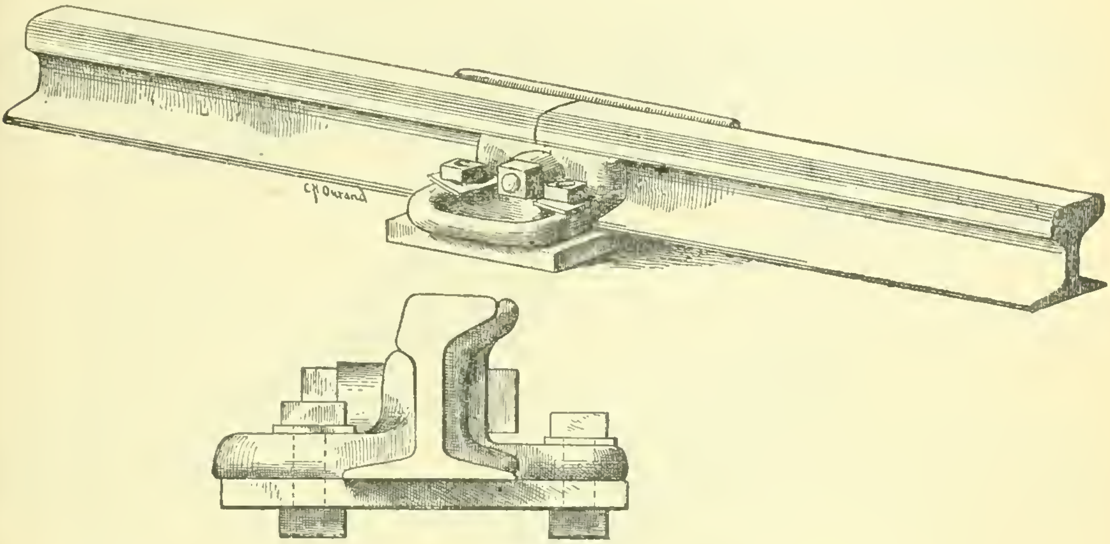

Fig. 130.
JOINT FIXTURE USED ON WESTERN RAILROADS, 1869.
(From original in the U. S. National Museum.)

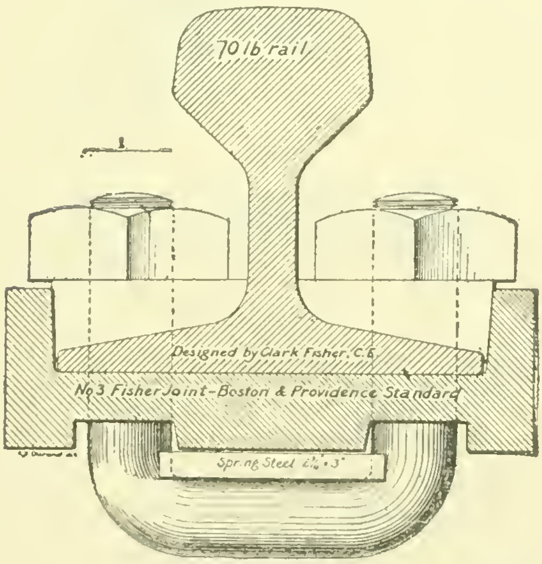

Fig. 131.
FISHER & NORRIS JOINT FIXTURE AS IMPROVED BY CLARK FISHER, 1888.
(From a drawing in the U. S. National Museum.)

PRIMITIVE FROGS.

Mr. Isaac Dripps, who in 1831 erected the locomotive John Bull at Bordentown, New Jersey (all of the parts of the engine having been made by Stephenson & Co., New Castle-on-Tyne, England), has furnished the information for Fig. 132, which illustrates the manner in which a large ⊓ shaped staple was made to take the place of a frog at the point where the "turn in" track branched off from the main line at the engine-house at Bordentown.

When it was necessary to take the engine out of the house the ∩ was straddled across the rail the two arms dropping into holes bored into the sleeper.

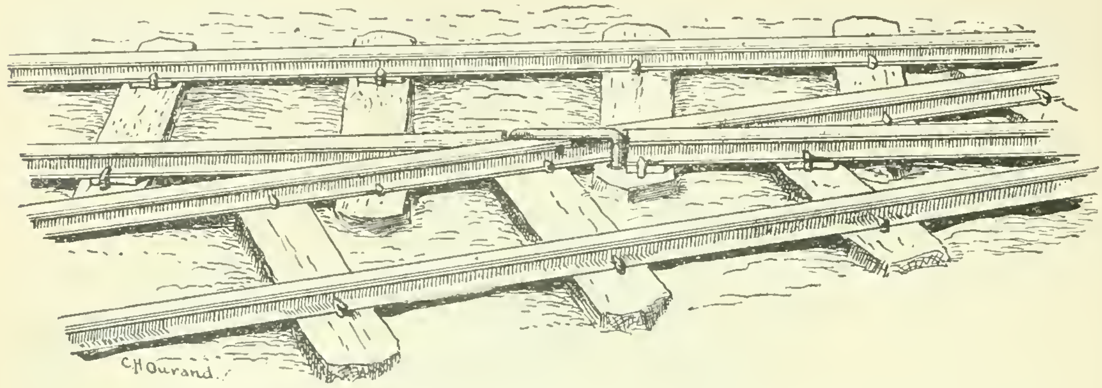

Fig. 132.

∩ STAPLE IRON USED AS A MAKESHIFT FOR A FROG, CAMDEN AND AMBOY RAILROAD, 1831.
(From a drawing in the U. S. National Museum.)

The iron of which the ∩ was made was thick enough to raise the flange of the locomotive wheel above the top of the rail. After the engine was safely put on the main track the ∩ was taken out, and both rails were right for the main line.

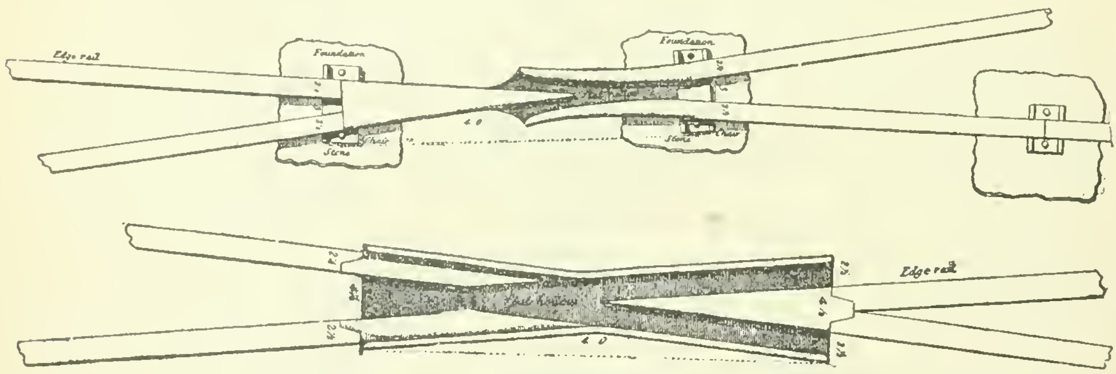

Fig. 133.

FROGS, COLLIERY RAILROADS OF ENGLAND, 1825.
(From drawings in the U. S. National Museum.)

Frogs of various shapes were used on the colliery roads of England previous to the introduction of the locomotive. Fig. 133 is from a drawing in the collection, which was made from the report made by William

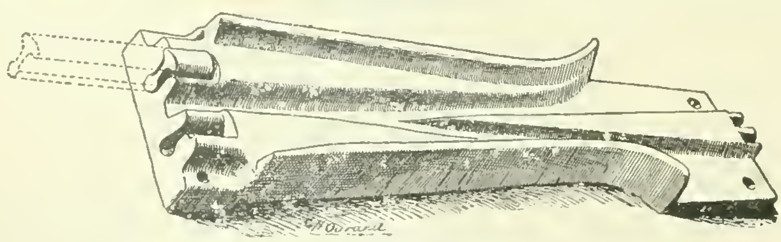

Fig. 134.

FROG, OLD PORTAGE RAILROAD, ABOUT 1835.
(From original in the U. S. National Museum.)

Strickland in 1826 to the Pennsylvania Society for Internal Improvement, in which two types of frogs, which he examined while in England in 1825, are illustrated and described. Fig. 134 is drawn from an old frog (deposited in the collection) which was laid on the old Portage Railroad about 1835. It will be noticed that the casting at the end of the frog is designed to fit the Clarence ⊤-rail previously described.

As the speed of trains increased, the cast-iron frog was found to be unsafe, and various forms of rail frogs were constructed. Fig. 135 is

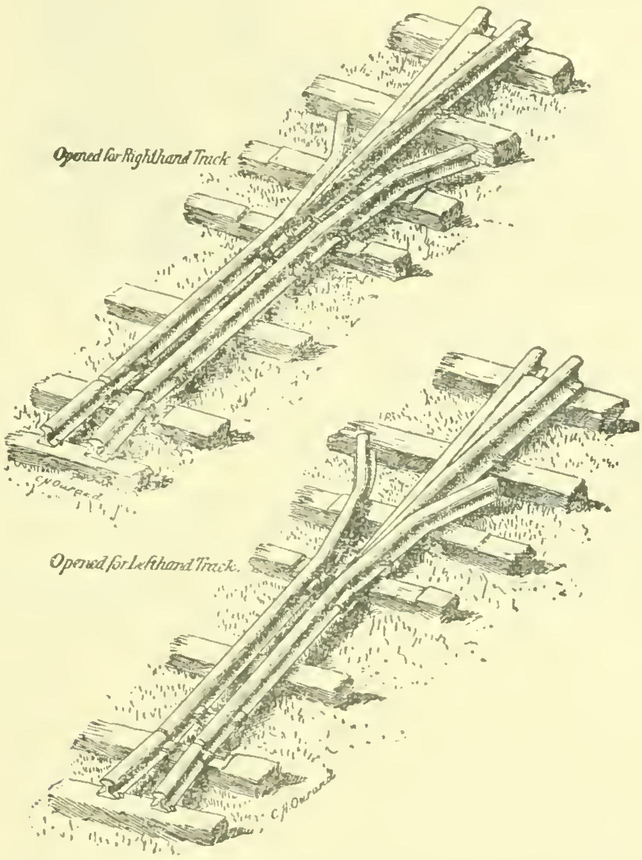

Fig. 135.
RAIL FROG, INVENTED BY JOSEPH WOOD, NEW JERSEY, 1859.
(From model in the U. S. National Museum.)

made from a model of an old rail (shifting) frog in the collection. This type of frog was invented by Mr. Joseph Wood, of Red Bank, New Jersey, in 1859, and formed the basis of the invention of many types of spring-rail frogs now in use.

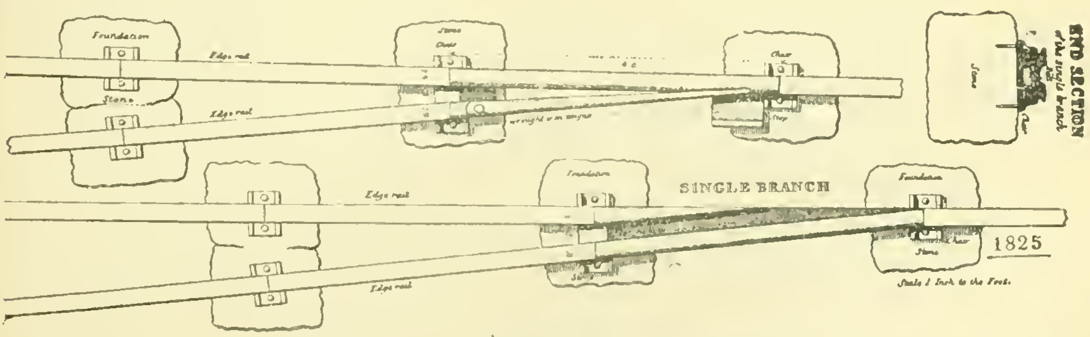

Fig. 136.
SWITCHES IN COLLIERY RAILROADS, ENGLAND, 1825
(From drawings in the U. S. National Museum.)

SWITCHES.

Two types of switches in use in England in 1825 are shown in Fig. 136. The drawings in the collection from which these are made are taken from Strickland's report, previously alluded to. Among the early forms of switches used in America was the lever switch, with the heavy iron counter-weight (see Fig. 137) to keep it in position. Sometimes

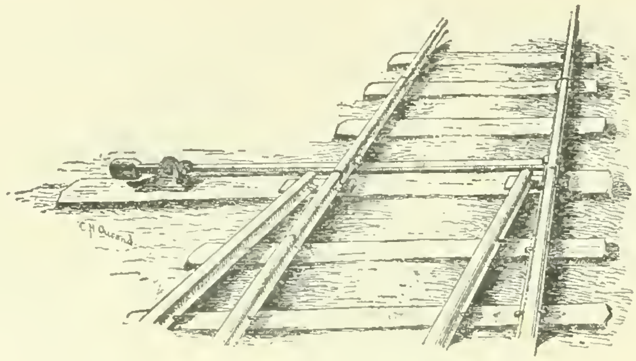

Fig. 137.
SWITCH WITH "BALL" COUNTER-WEIGHT.
(From a drawing in the U. S. National Museum.)

the "ball" was omitted, and the lever was secured by a padlock fastened to a staple driven into a cross-tie.

It is to be hoped that an opportunity may be given to extend the collection of frogs and switches in the near future, so that the history of the development of these two very important track-appliances may be preserved.