ABOUT RAILS

A FEW NOTES ABOUT STEEL RAILS AND RAIL RECORDS

ENGINEERING DEPARTMENT

THE WESTERN PACIFIC RAILROAD CO.

1953

This booklet has been compiled by the Engineering Department, for use of roadmasters, section foremen, and other maintenance-of-way personnel, so they may have a clearer understanding of the rail they handle and care for daily

The Colorado Fuel & Iron Corporation has given valuable aid in the preparation of the booklet, particularly in verifying technical details and terminology.

The first chapter describes the process of manufacture used for most of the rail sections used on the Western Pacific; the older 100, 110, 112-pound sections and the currently used 115-pound section. (The description also fits the 132-pound section used in a few locations, except that only five rails can be rolled from an ingot, instead of six as described.)

The second chapter deals with the performance of rails in track.

CHAPTER I

MANUFACTURE OF STEEL RAILS

The Open Hearth

Western Pacific's rail is made by the "Open Hearth" method, most of it at the Colorado Fuel & Iron Corporation plant at Pueblo, Colorado. The open hearth is a huge furnace of steel and brick, which is capable of handling slightly over 100 tons of molten steel at a time. Colorado Fuel & Iron Corporation has sixteen open hearths. Each one has a set of oil or gas burners which are capable of maintaining a temperature of over 3,200 degrees Fahrenheit inside the open hearth.

The Heat

Each batch of steel produced in an open hearth is called a "heat." Materials necessary to make steel are primarily pig iron, scrap, ore, and limestone. All the ingredients of a heat are loaded in oblong steel "Charging Boxes" which are loaded on narrow-gauge cars and hauled to the open hearth. A "Charging Machine" picks up each box, shoves it through the

"Charging Door" of the open hearth, turns it upside down, and withdraws it. Under the intense heat of the flames, the mixture melts down into a bubbling white-hot liquid.

At precisely the proper moment, an opening is made in the open hearth, and the entire hundred or more tons of molten metal are allowed to run into a large brick-lined ladle. This is called "tapping the heat."

Work begins immediately, to charge the next heat. Each open hearth can produce about two heats every twenty-four hours.

Due to the nature of the operation, it is impossible to make the heats exactly alike. Therefore, a careful record is kept of each heat; its weight, its ingredients, its temperature, etc. One ingredient particularly important to the railroads is carbon. This is because, while the total carbon content is less than one percent of the whole, it adds to the hardness and toughness of the steel. The railroads select the rails with the higher carbon content for use where the wear is greatest, such as on curves, etc.

If the final quality of the heat does not measure up to the rigid specifications for rail, it is slated for some lower-grade product like tie plates.

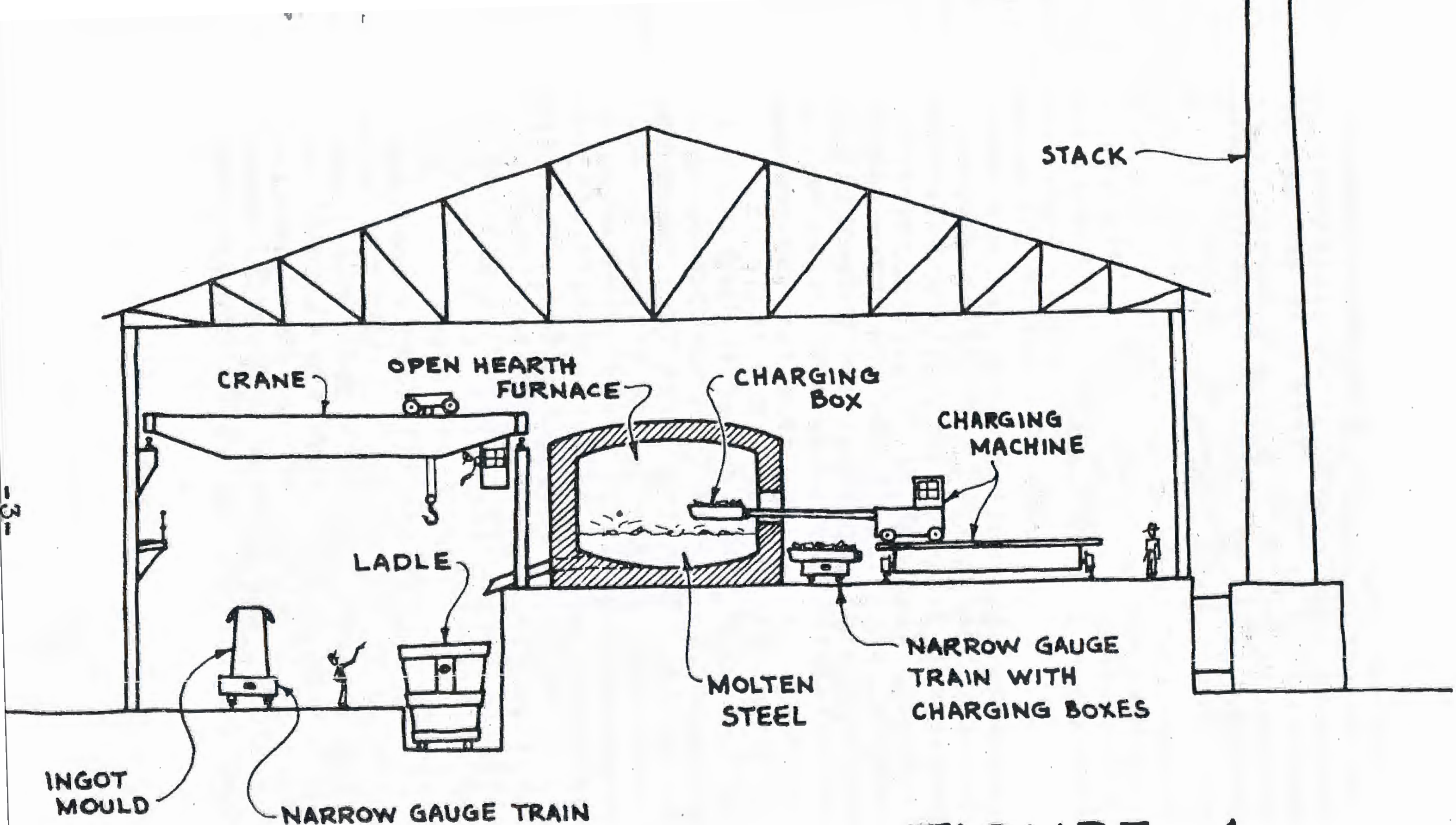

STACK
CRANE
OPEN HEARTH FURNACE
CHARGING BOX
CHARGING MACHINE
LADLE
MOLTEN STEEL
NARROW GAUGE TRAIN WITH CHARGING BOXES
INGOT MOULD
NARROW GAUGE TRAIN

FIGURE 1

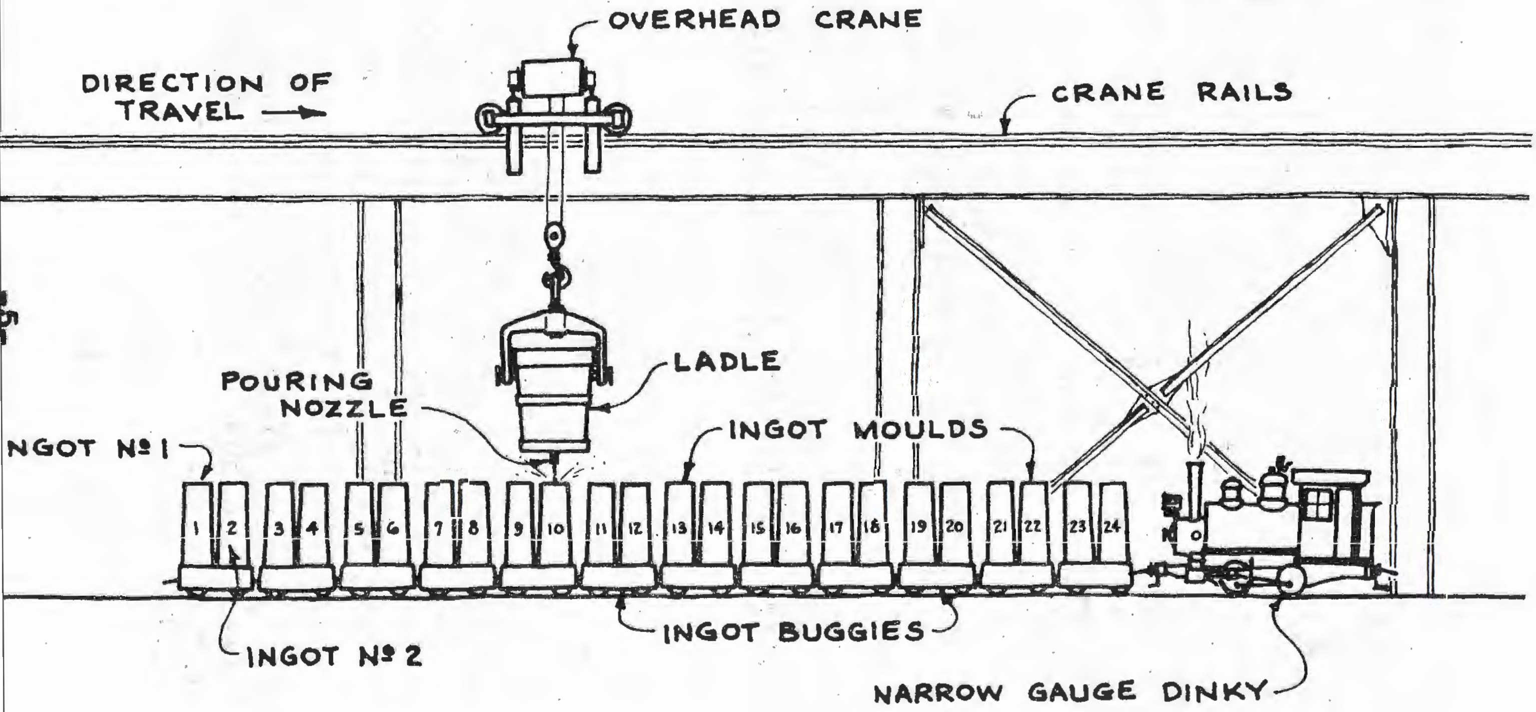
Colorado heats are numbered consecutively by open hearths. For instance, Heat No.8342 is the 342nd heat produced in Open Hearth No.8 during the year. Likewise, Heat No.16036 would be the 36th heat out of Open Hearth No.16.

The Ingot

After the molten metal has run from the open hearth into the ladle, an overhead crane picks up the ladle and carries it to the ingot molds. These molds are vertical cast iron boxes about two feet square inside and about seven feet high. About twenty-four molds are placed on narrow-gauge railway cars for the pouring or "Teeming" process. The ladle is spotted over the first of the molds, and a stopper is lifted from the bottom of the ladle. When the first ingot mold has flowed full of steel, the stopper is replaced and the ladle moves over to the next ingot mold. An average heat will fill from 19 to 23 ingot molds. The first ingot poured becomes Ingot No.1, and succeeding ingots are numbered in the order they are poured.

The ingots are allowed to cool and solidify in the molds. During the solidifying process, the outside of the ingot cools more rapidly than the inside, because it is closer to the atmosphere. Therefore, the outside solidifies sooner than the inside. As we all know, steel

FIGURE 2


OVERHEAD CRANE
DIRECTION OF TRAVEL
CRANE RAILS
LADLE
POURING NOZZLE
INGOT MOULDS
INGOT Nº 1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
INGOT Nº 2
INGOT BUGGIES
NARROW GAUGE DINKY

shrinks as it cools; so, as the outside cools and shrinks, the still molten metal at the center settles downward to fill the space created by the shrinkage. This settling process causes a cavity to appear at the top center of the ingot. This cavity is called the "pipe." Sometimes the bottom tip of the pipe dies out in a string of little cavities or bubbles in the ingot. We shall see later how this pipe becomes a problem in the rolling process.

The solidified ingots are hauled to the "Stripper," a large machine which lifts the mold from each ingot. The ingots are still red hot during this process.

The ingots can now be stockpiled; however in the case of rail steel they are hauled to the rolling mill immediately to conserve the heat remaining in them.

Soaking

The ingots, upon arrival at the rolling mill, are lowered into large ovens called "Soaking Pits." The temperature in the soaking pits is carefully adjusted to heat the ingots to the exact temperature required for rolling.

As each glowing five-ton ingot is lifted from the soaking pit by a gigantic pair of steel fingers, it enters the rolling process.

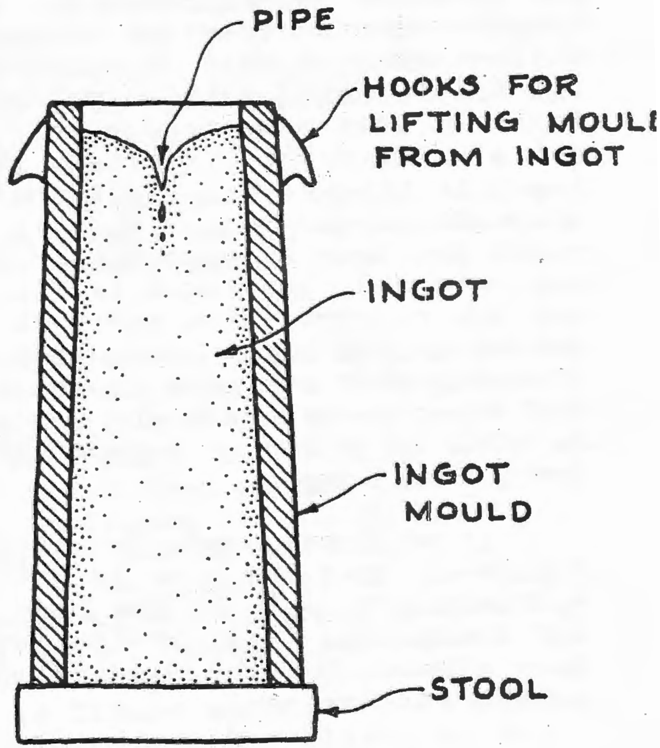

PIPE
HOOKS FOR
LIFTING MOULD
FROM INGOT
INGOT
INGOT
MOULD
STOOL

FIGURE 3

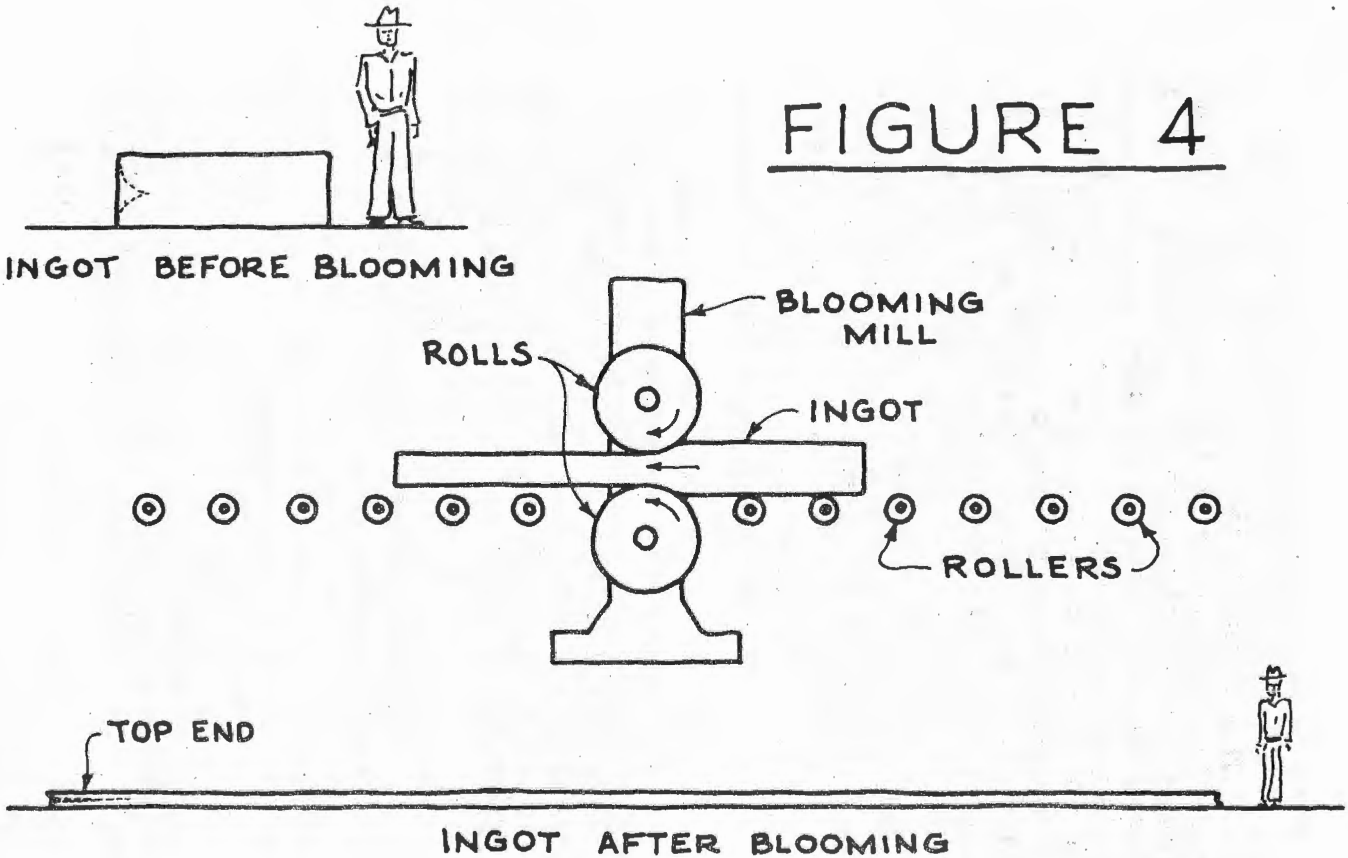
Blooming

The ingot is laid on its side, on a set of power driven rollers. The rollers trundle the ingot to the "Blooming Mill," a large machine that is faintly reminiscent of a washing machine wringer. The ingot is forced between a pair of steel rolls which are a bit closer than the ingot is thick. The ingot comes out a bit thinner and longer than it was. The rolls are then brought closer together and reversed, the ingot is flopped over, and the rollers which carry it are reversed so the ingot heads back to the Blooming Mill and gets squeezed again. The ingot passes back and forth until it is about nine inches square and about fifty feet long.

It will be noted, by referring to Figure 4, that the pipe is still present in the ingot, only it has been narrowed and elongated. Most of the cavity has been closed, but the discontinuity of the metal still exists.

The ingot has now been reduced to a size where it becomes necessary to start shaping the rail. Before starting on the shaping process, the ingot is cut into two pieces, because, if the full ingot were to be rolled in one piece, it would result in a rail over 200 feet long, which would be too unwieldy to handle. The cutting is done on the "Blooming Shears," a machine that literally bites off the nine-inch-square bloom.

FIGURE 4


INGOT BEFORE BLOOMING
BLOOMING MILL
ROLLS
INGOT
ROLLERS
TOP END
INGOT AFTER BLOOMING

The first bite is made at the top end, far enough back to include the pipe. The piece which contains the pipe, called the "top discard," is conveyed out and scrapped. Sometimes an ingot with an extra long pipe gets by with some of the pipe remaining, which condition is detected later, as we shall see. The ingot is then cut in two at about its midpoint and another cut is made near the bottom end to remove the imperfect butt called the "bottom discard." The two pieces remaining are called "Blooms." These blooms, still red hot, continue on to be rolled into three rails each.

Roughing

The bloom now approaches the "Roughing Stand," a rolling mill similar to the Blooming Mill, except that the surfaces of the rolls are shaped so that, with each pass through the rolls, the bloom begins more and more to resemble a rail. It also grows in length as its sectional area is reduced. After nine trips back and forth, the bloom is ready for its finishing pass.

Finishing.

The almost-finished rail now goes to the "Finishing Stand" for its final rolling. The bottom roll in the Finishing

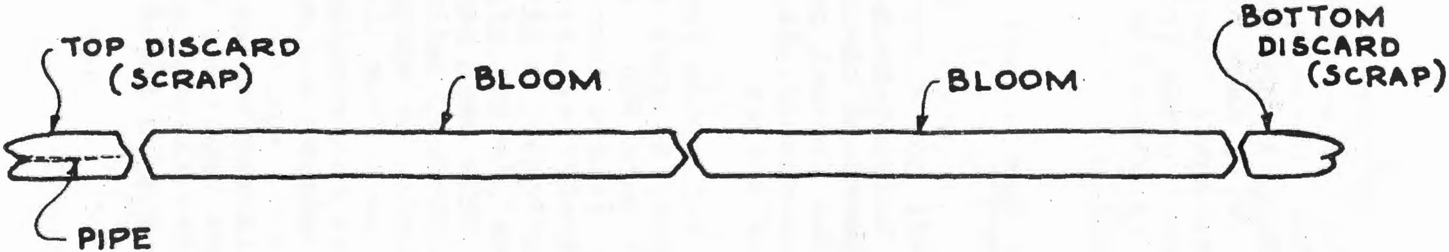


FIGURE 5

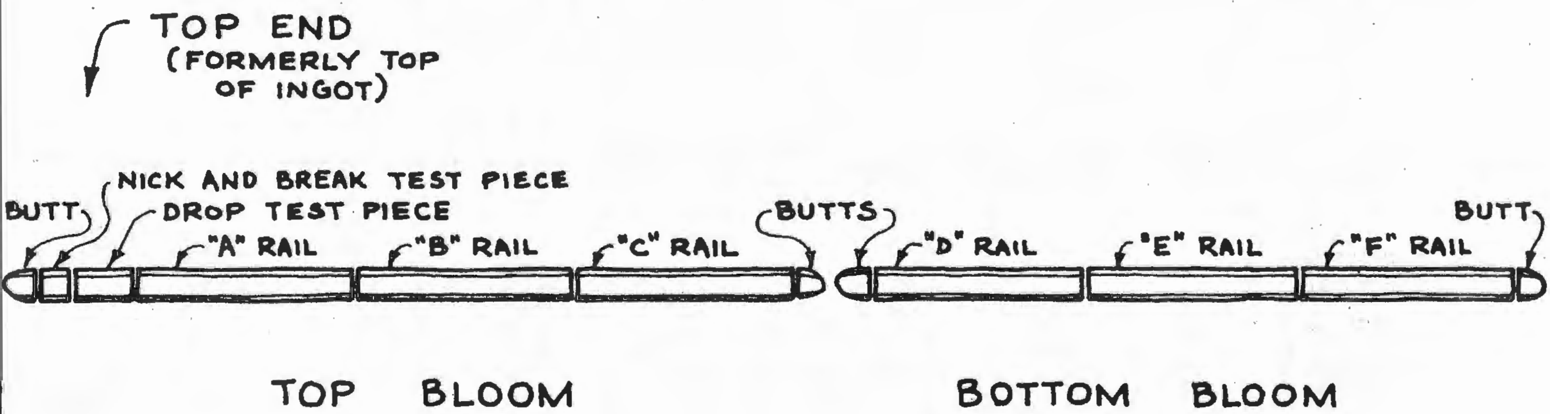
Stand has carved into its surface the letters which form the "Branding" of the rail, which shows the year and month rolled, size of the rail, name of the mill, and "CC" to designate "Control Cooled." When the rail comes from the finishing stand, it is about 130 feet long.

Hot Saw

The finished rail now approaches the "Hot Saw" to be cut into 39-foot lengths. The hot saw is a high-speed circular saw which cuts through the red-hot rail section in less than one second, in a spectacular shower of sparks.

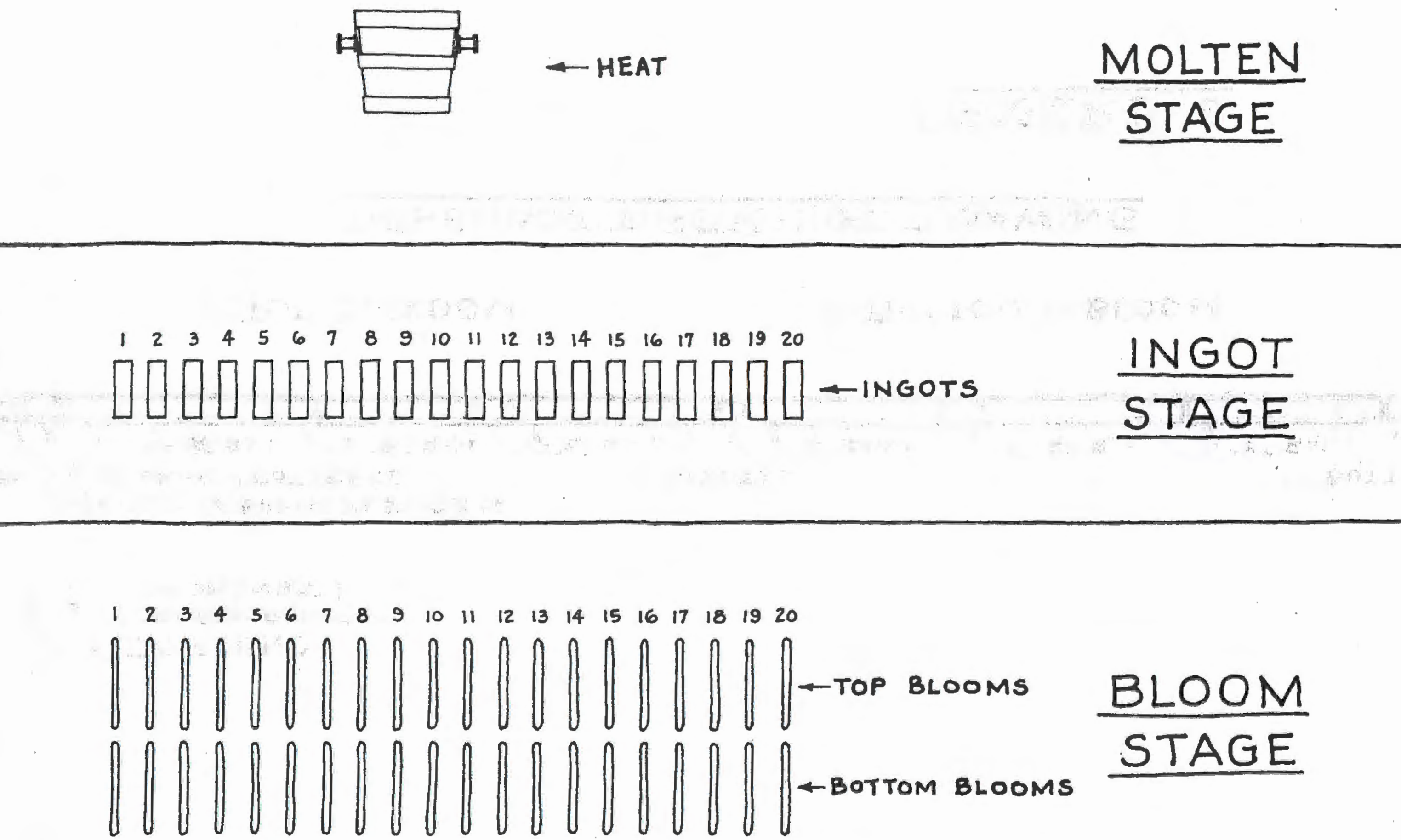
The section of rail made from the top bloom is first cut near the top end, to remove the imperfect butt end. Next a piece about fourteen inches long is cut off as a "Nick-and-Break Test Piece." On about every tenth ingot, a five-foot-long "Drop Test Piece" is cut off the rail from the top bloom. The main section is then cut into three 39-foot rails, and the short butt end remaining is scrapped. The section of rail made from the bottom bloom of the ingot is cut similarly, except that no test pieces are cut.

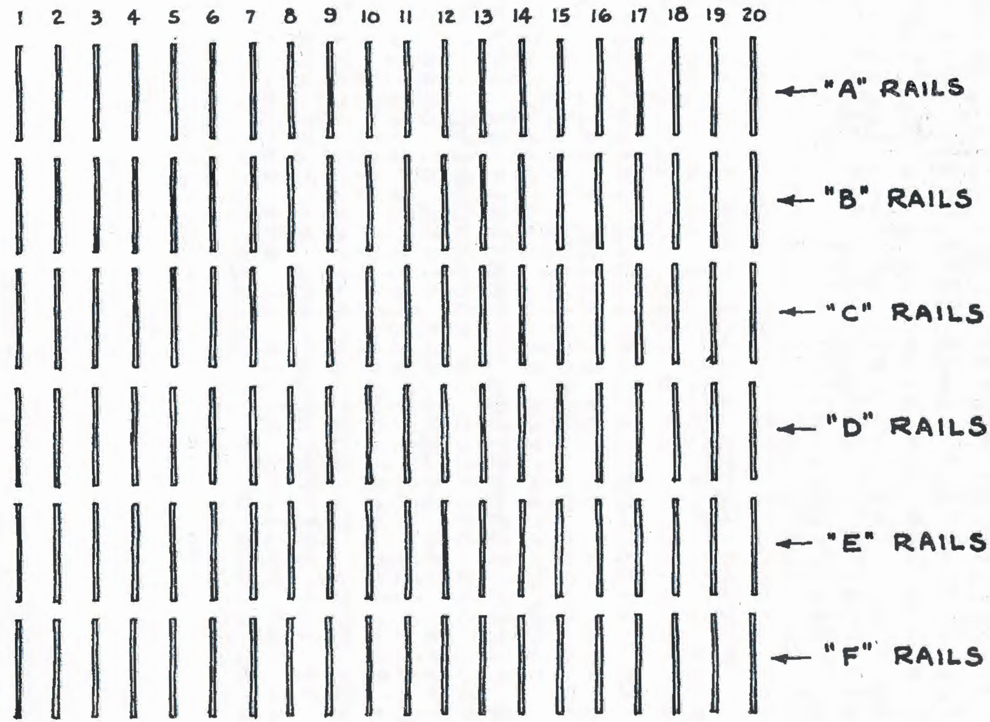
One 39-foot rail leaves the hot saw every 25 seconds, and each rail has spent about 5½ minutes under the rolls since leaving the soaking pit in ingot form.



THE INGOT AFTER HOT SAWING

FIGURE 6


HEAT
MOLTEN STAGE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
INGOTS
INGOT STAGE
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
TOP BLOOMS
BOTTOM BLOOMS
BLOOM STAGE



FINAL STAGE

FIGURE 7

Stamping

The six rails which have come from the ingot are carried on rollers from the hot saw to the "Stamping Wheel." Each rail, which is lying on its side, with the branded side down, is stamped on its upper side, in the web, with its heat number, ingot number, rail letter, and letters "CC" (which designate control cooled rails), or "CH" (which designate control cooled end hardened rails), by a wheel which has the stamping dies mounted on its rim. The top rail of each ingot is lettered "A", the next one "B", and so on. (See Figure 6)

Section Inspection

An inspector is stationed where the rails come out of the stamping wheel. He removes one red-hot rail for every heat, from the roller line, and subjects it to rigid inspection. The rail is weighed, its section is checked with templates, its height and width of base are measured, and its surface is scrutinized for defects. This inspection is witnessed by the Western Pacific man and also by the millwrights, who go back and adjust the rolling mills if any variations or flaws show up in the rail.

The Hot Bed

The rails, now finished with the rolling process and still red hot, are carried on rollers to the "Hot Bed." This is nothing more than a set of skids on which the rails are lined up, side by side, for cooling. The rails are allowed to lie there until they cool to just under 1,000 degrees, the temperature at which they lose the last of their red color.

Control Cooling

The rails are then picked up by large magnetic cranes and lowered into insulated steel "Control Cooling Boxes," each one big enough to hold 100 rails. A lid is put on each box as it is filled, and the box is not opened for at least ten hours, until the rails are under 300 degrees. This process is called "Control Cooling" and its purpose is simply to slow down the cooling of the rails between the temperatures of 725 and 300 degrees.

Control cooling was first used in the late 1930's to combat the "Transverse Fissure." Every section foreman is more familiar with transverse fissures than he cares to be. It is a mysterious "disease" of the rail, which starts without warning inside of the rail, grows erratically, then causes a sudden break of the rail.

Rail detector cars were developed to find these fissures in their growth stage, and most of them are found before the rail breaks.

Meanwhile railroad and steel industry engineers were conducting exhaustive tests to find out what causes transverse fissures and how they can be prevented. They were finally tracked down to "Shatter Cracks" caused by hydrogen gas trying to escape from the steel during its cooling stage. The engineers found that, by retarding the rate of cooling, occurrence of shatter cracks was eliminated. Steel mills all installed cooling boxes and today virtually all rail produced is control cooled. Western Pacific has bought only control cooled rail since the beginning of 1938, and to date there has been not one single transverse fissure found in rail bought since then. Rail rolled before 1938 is being eliminated each year, and soon the transverse fissure will be a thing of the past on Western Pacific.

As we were saying - the rails were taken from the hot beds and sealed in the control cooling boxes for ten hours. While we are waiting, let us go back and see what is done with the test pieces that were cut from the top rail of the ingot at the hot saw.

Nick-and-Break Test

The fourteen-inch-long pieces of rail which were cut from the top rail of each ingot are stamped with the number of the heat and ingot from which they came, and they are nicked in the center with a chisel. The pieces are piled up until all the specimens from the heat are together, and then a water hose is turned on them, to cool them off. Each piece is then put under a press and broken in two, through the chisel nicks.

The broken ends of the test pieces are carefully studied by a mill inspector and a Western Pacific inspector. If there is any pipe present in the test piece, it will show up plainly in the broken end. A pipe in the test piece indicates that the blooming shears and the hot saw did not discard all of the imperfect top end of the ingot, and it also indicates a strong possibility that the pipe extends into the top or "A" rail. All pieces showing pipe are listed and we shall see later how the list is used.

Drop Test

The five-foot-long drop-test piece of rail which is cut from the top end of the second, middle, and last ingot of every heat, is stamped with its identification, and is put into a miniature "control cooling box" so that it cools under the same conditions as the rails it represents. When it is cold, it is placed under the "Drop Test Machine." The piece rests "Head" up on a pair of supports which are four feet apart, and a one-ton weight called the "tup" is allowed to fall on it from a height of twenty feet. An inspector measures the amount that the rail has bent under the blow. A 115-lb. rail will usually take a 3/4" permanent set at the first blow. Every third drop-test piece is given a total of five blows to see how it stands up under such punishment. Most rails will bend through 45 degrees without breaking. This test is also witnessed by the Western Pacific inspector.

If a drop-test piece should break under the first blow of the tup, all of the "A" rails of that heat are rejected and scrapped, and another drop test is made of the "B" rails.

Straightening

Going back now to the control cooling boxes, we find the rails, now under 300 degrees, being lifted from the boxes and sent on their way to the "Finishing Mill." The first finishing operation is at the "Straightening Presses."

Rails are quite crooked after cooling, because of the handling they have received while hot and soft, and because of the cooling stresses. Each rail is moved under a press on rollers. The "Straightener" stands at the end of the rail and squints along it against a strong light. He determines where the "crooks" are and signals to his assistant the "Gagger" where to apply the pressure to straighten the rail.

The straightener, when squinting against the light, sometimes discovers "blister" flaws in the rail. Blisters are the final form of the little bubbles which occur at the bottom tip of the pipe in the ingot, and are closely related to pipe. These little bubbles are rolled flat in the rolling process, but they open up in the cooling, to form low bumps in the web of the rail, and are detected in the course of inspection.

Milling and Drilling

The straightened rail goes to a pair of milling machines which smooth the ends of the rail and cut off the rough burrs left by the hot saw.

The rail then moves to a pair of multiple drill presses which drill the bolt holes.

End Hardening

After drilling, the rail moves under a set of burners which heat about 2-1/2 inches of the top of the rail at each end. When the metal reaches red heat, it is subjected to a sudden jet of cold air. This treatment hardens the metal of the rail where it is subjected to the pounding of car wheels as they jump over the gap between rails.

End hardening is a development which reduces end batter and low joint conditions, thereby considerably reducing wear in the joint-bar area.

Inspection

The rails, which are now ready for track except for end beveling and filing, are laid out in groups of 60 or 70 for inspection. Men with air grinders and files touch up the ends of the rails during the inspection operation.

Two men called "Rail Turners" turn the rails so their bases are up, and a pair of mill inspectors called "Rail Walkers," and the Western Pacific inspector, walk back and forth on the inverted rails, searching them for flaws. If a large flaw is found, the rail is marked for scrapping, or, if the flaw is near enough to the end of the rail, it is marked for cutting back. If a minor flaw is found, the rail is classified as a No.2 rail.

The rail turners then turn the rails on their sides so that the stamped side is up. The inspectors then refer to their notes and mark each rail as to whether it is high or low carbon. They also refer to the list of ingots which showed pipe in the nick-and-break test. The "A" rails of these ingots are found and marked for special attention.

The rails are then turned head up, and again the inspectors walk back and forth, searching and marking. The inspectors then inspect the ends of all "A" rails for pipe, with particular attention to those which showed pipe in the test piece.

The last check is made for "crooks," the term used for crooked rails, by squinting along each rail from each end.

Three crews of inspectors are required, to handle the work, and the Western Pacific man spends part of his time with each crew.

Painting

At the completion of the inspection, the rail turners paint the ends of the rails in accordance with the inspectors' chalk marks. All the No.2 rails are painted white and a "2" is stamped on each end of each rail. All "A" rails are painted yellow. "A" rails are separated from the other rails because they come from the top of the ingot, which is considered the least desirable. Scrap rails are painted red. High carbon rails are painted blue, and low carbon rails are left unpainted.

Sorting and Loading

An overhead crane, equipped with magnets which can pick up thirteen rails at a time, sorts each bed of inspected rails. Red rails are dumped on a car and routed back to the open hearth, for remelting. White, yellow, blue and plain rails are sorted and loaded on cars for shipment to the customer.

"Crooks" are taken to the "Restraightening Press" and are reinspected, painted and loaded.

Rails marked for cutting back are taken to the "Cold Saw," where the defective end is cut off, and the rail is redrilled.

Short rails coming from the cold saw are reinspected, painted green, and loaded.

It is interesting to note that the mill has no provision for carrying a stock of rail. Rails must be loaded on cars immediately, as they are finished, or a serious "traffic jam" occurs in the inspection and loading area.

Records

As the cars of rail leave the steel mill, the Western Pacific inspector telegraphs the car numbers, contents, and departure dates to the General Office, so that arrangements can be made to unload the rail as soon as it shows up.

The inspector then sits down at his desk at the mill and prepares a very important record. This record shows, in very compact form, the history of every heat of rail that was rolled for Western Pacific. The information is entered on two sides of a 5" x 8" card which will later be filed in the Engineering Department, to remain there for the entire life of the rail.

Figure 8 shows the front side of the card, filled in to show an imaginary heat. While few cards show so many defects, we have made the entries here to show the simple code that is used.

Referring to the card, we see right away that the card covers Heat 16036 which was rolled into 115-lb. rail in 1952, at CF&I, to Western Pacific's Purchase Order No.11699-951-RE, dated November 30, 1951.

We can see that there were 21 ingots cast from the heat. We also see that "Drop Test" pieces were cut from Ingots 2, 10, and 21. No.2 was given one blow and

RAIL HEAT RECORD

HEAT NO. 16036	WT. RAIL 115
P. O. NO. 11699-951-RE 11-30-51	TONS 8640
MILL C.F.&I.	YEAR 1952

DROP TEST AND NICK & BREAK TEST

ELONGATION BY INCHES .06 | .07 | .08 | .08 | .07 | .06 TOTAL .42

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BLOWS		1								1											5		
SET		.85								.80											.80		
FRACT.																							
N. & B.	K	K	K	P	K	P	P	K	K	K	K		K	K	K	K	K	P	K	K	K		
A				36'P		K	///P		30'B		///B	0		33'B				33'P					
B												0								#2C			
C												0			#2C								
D		COB.		///M								0							///C				
E		COB.								#2M		0	///C										
F	///D	COB.										0											

took a permanent set of .85 of an inch. No.10 also received one blow and set .80 of an inch. No.21 was given five blows and set .80 of an inch after the first blow. If the piece had broken on say the fourth blow, the entry in the "Blows" line would have been "4B" and the nature of the fracture would have been entered on the line marked "Fract."

The line marked "N&B" shows the outcome of the "Nick-and-Break" test. We can see that Nos.4, 6, 7, and 18 showed pipe (P) and that all the others were OK (K). There was no test made for Ingot No.12, for the reason that the ingot was omitted (O); that is, Ingot No.12 was not rolled into rails because of some defect.

Looking at Ingot No.4 a bit closer, we see that, in addition to the pipe in the Nick-and-Break test, the "A" rail also showed pipe, and that it was cut back to a 36-foot rail to eliminate the pipe. Likewise the "A" rail of Ingot No.18 was cut back to eliminate pipe. The pipe in Ingot No.6 was not serious because the "A" rail was clear; however, in Ingot No.7 we find the entire "A" rail scrapped on account of pipe. (The three little lines mean "scrap")

Ingots 9 and 14 evidently had some blister present, for we see the "A" rails cut back to 30 and 33 feet for blister (B). Rail 11-A also had a blister, but it was close to the middle of the rail, so it was scrapped.

Something must have gone wrong with the bottom bloom of Ingot 2 in the rolling process, for we see that the D, E, and F rails are marked "COB" (Cobbled). Such cobbled rails are usually fished out of the machinery, partially rolled, and are scrapped.

Rails 10-E, 15-C, and 20-B were classified as No.2 white rails, one of them marked "M" (Mechanical) for a rolling defect, the others marked "C" (Common) for defects that were in the steel before rolling. Rails 4-D, 13-E, and 19-D were scrapped for the same kind of defects but of a more serious nature.

Rail 1-F was scrapped on account of being damaged (D). It may have been dropped by a crane or banged against a car while loading.

So - of the 126 possible rails in the heat, Western Pacific received only 111, and, what is more important, we know which of the 126 we didn't get and why.

The reverse side of the card shows a lot of technical data which we will not attempt to explain.

HEAT NO.	16036
YEAR	1952

CHEMICAL ANALYSIS

CARBON	MANGANESE	PHOSPHORUS	SULPHUR	SILICON
.74 - .74	.82 - .81	.019	.039	.14

OPEN HEARTH

DATE 1-28-52	ADDITIONS TO LADLE: Mn. 2400, Sil. 900, Co. 200	MINS. LADLE HELD 0 39	COND. MOLDS Good	NO. FULL INGOTS 21
WEIGHT OF HEAT 222,800			TEEMING O.K.	SHORT INGOTS —
			COND. INGOTS O.K.	BUTTS AND STICKERS 0 - 1

BLOOMING

	TIME INGOTS IN MOLD	HEATING O.K.	
NO. OF INGOTS BLOOMED 20	TRACK TIME 5 25	BLOOMING O.K.	
NO. BLOOMS PER INGOT 2	TIME IN PITS 4 50	COND. BLOOMS O.K	

SHEAR DISCARD		SAW DISCARD	
TOP	BOT.	TOP	BOT.
6.5	4.4	1.2	.6

ROLLING

	NO. RAILS SCRAPPED 6	TOTAL NO. 1 RAILS 108	TOTAL SHORT RAILS 4
TOTAL RAILS ROLLED 117	NO. RAILS SHIPPED 111	TOTAL NO. 2 RAILS 3	TOTAL "X" RAYLS 0

SLOW COOLING

BOX NO.	NO. RAILS	INGOT NUMBERS	TEMP. CHGD.	TEMP. 7 HRS.	TEMP. DRAWN	TIME IN BOX
5	75	1-14 (Omit 12)	860-990	470	300	16 30
20	42	15-21	860-995	460	300	16 15

REMARKS:

FIGURE 9

W. P. FORM #2700 1M-2-51 NG BY E.T. DATE: 2-3-52

If the heat is good, and its rails give normal service, this information on the back of the card will probably never be looked at again. However, if the heat should give trouble later, both railroad and steel mill people will be intensely interested in the information.

With the completion of the cards, the inspector comes home, the cards are filed, and the rail is laid in track, and another chapter is written in the Western Pacific's never-ending improvement program.

Now let us go back and see why that rail was bought in the first place. Rail is pretty expensive material, and it is certain that railroads do not buy it unless they are quite sure they need it. And, when approval is sought from the Board of Directors, for a rail expenditure, the Board needs something more to consider than one man's word that he thinks it is about time that a certain section of track got new rail.

The following chapter will attempt to explain how the Engineering Department keeps a current set of records that show at a glance the condition of the rail over the entire system, and how these records automatically indicate when any section of track should be considered for rail renewal.

If the head is good, and its [illegible] [illegible] [illegible] [illegible] [illegible] the head [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

With the completion of the [illegible], the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] purpose.

Now let us look back and examine the [illegible] [illegible] [illegible] in the first place. [illegible].

The following chapters will attempt [illegible].

CHAPTER II

RAIL PERFORMANCE RECORDS

Rail Life

Rail, like almost any other mechanical thing, is usable until it is either worn out or broken.

The wearing-out of rails is less of a problem than the breaking of rails. The wear is gradual and predictable; the breaking is sudden and unpredictable.

Wear of Rails

The "wear life" of a rail is reckoned in "gross tons," that is, the number of tons of locomotives, cars, and loads rolling over the rail that it takes to wear it out. This is ordinarily called the "Tonnage Life" of the rail.

The Engineering Department has a set of established figures that show the Estimated Tonnage Life of each size of rail on tangent track. For instance, the old 85-lb. rail had an estimated life of 185,000,000 gross tons, and the 115-lb. control cooled rail now in use is estimated to carry 325,000,000 gross tons. These figures are only a rough guide, as the actual life of the rail is subject to many conditions. Rail on curves will naturally wear out much before the estimated life of tangent rail is reached. Maintenance is a major factor in the life of rail. Where the track is maintained in good line and surface, with tight joints, this rail will last much longer than other rail not so properly cared for. Despite all these variables, the "Estimated Tonnage Life" figures have served successfully as an aid to foreseeing future rail requirements, when used together with charts showing traffic handled in the past and predicted traffic for future years.

The number of years that rail has been in track has very little to do with the need for replacing it.

Failure of Rails

When a stretch of rail becomes worn, it can always be made to do for another year or two, if money is not available or if rail is needed more elsewhere. However, when a stretch of rail begins to show excessive failures, the matter becomes urgent because safety is involved. Fortunately most rail will not begin to show an appreciable number of failures until it is nearing the end of its "Tonnage Life."

It is obvious that some record must be kept of rail failures, in such a way that an over-all picture of the failure situation may be had at all times. The record is kept by the Engineering Department, and the next few pages will explain how it works.

This record starts with the section foreman, who removes the failed rail from the track. He identifies the failure, either from experience if it is a common type of failure, or by referring to his "Rail Failure Manual" if the failure is unusual or complicated. He then fills out a "Rail Failure Report," which finds its way to the Engineering Department via the Roadmaster and Division Engineer.

When the report arrives at the Engineering Department office in San Francisco, it is given to an engineer who records it. First he gives it a serial number, and then he converts the location of the failure to decimals of a mile. These figures are entered on the report as shown in Figure 11.

A 3"x5" "Rail Failure Record" card is then filled out, showing in brief form the identity of the rail and a description of the failure. This card puts the record of the failure into a handy reference form. The serial number of the report is shown on the card so that the report may be looked up when more information regarding the failure is needed. (See Figure 12)

THE WESTERN PACIFIC RAILROAD CO.
RAIL FAILURE REPORT

DIVISION Eastern	DISTRICT 3rd	SECTION NO. 31	REPORT NO.	DATE 3 - 13 - 52

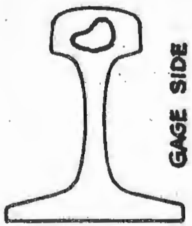
WT. RAIL 112	CONTROL COOLLED? No	MILL G & B	YEAR 1936	HEAT 9176	LETTER B	INGOT 4

LOCATION M.P. 585 + 63 RAILS	TANGENT OR CURVE? Curve	DATE & TIME FOUND 3-13 4:30 AM
NEAREST STATION Russell Spur	HIGH OR LOW RAIL? High	DATE REMOVED 3 - 13 - 52
WHICH RAIL? North DEG. CURVE 2°30'	WAS RAIL IN TRACK CIRCUIT? yes	TRACK, M. L. OR SIDING M.L.

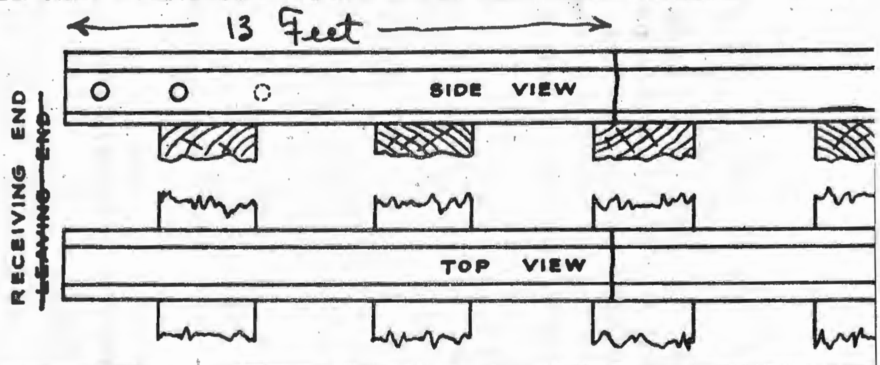
RAIL USED IN PLACE OF RAIL REMOVED

WT. RAIL 112	CONTROL COOLED yes	MILL C.F. & I.	YEAR 1942	HEAT 13397	LETTER C	INGOT 2

DESCRIBE FAILURE, AND FLAWS OR DEFECTS, AND STATE CAUSE. DRAW DEFECTS AND LINES OF BREAK OR FRACTURE ON DIAGRAMS. IF TRANSVERSE FISSURE, SHOW PERCENTAGE.



30% Transverse Fissure



IF ACCIDENT OR DELAY TO TRAINS WAS CAUSED BY FAILURE, STATE CIRCUMSTANCES:

Ex 917 A East delayed 35 minutes

CORRECT: John R. Doe FOREMAN	APPROVED: Jake P. Jones ROADMASTER

The "Rail Failure Record" card is then filed in milepost order among the previous cards. This file of cards, which currently fills two 12-inch-deep drawers, forms a valuable record. If, for instance, we wish to know how many and what types of failure are occurring in a section of track between two certain mileposts, we need only to extract the group of cards between these mileposts, and thumb through them. The cards show only failures which have occurred since the last rail change in any area, because the cards are weeded out as the rail is changed.

Next, the rail failure is plotted on a file called "Rail Failures per Mile of Track." This file has one 3"x5" card for every mile of track. The failure at milepost 585.47 is plotted on the card marked "585" shown in Figure 13, which covers track between MP 585.00 and 585.99. Since there are in this case no previous entries for 1952, the engineer writes the year in the proper column, and enters the figure 47 in the first box above the year column. This figure shows the location of the failure within the mile. If the failure is of a serious type, such as transverse fissure, compound fissure, or detail fracture, the box is colored yellow.

Glancing over the card, we have a picture of how the rail in this mile has behaved since it was installed. We see that there were no failures at all during the first eight years of its life, and

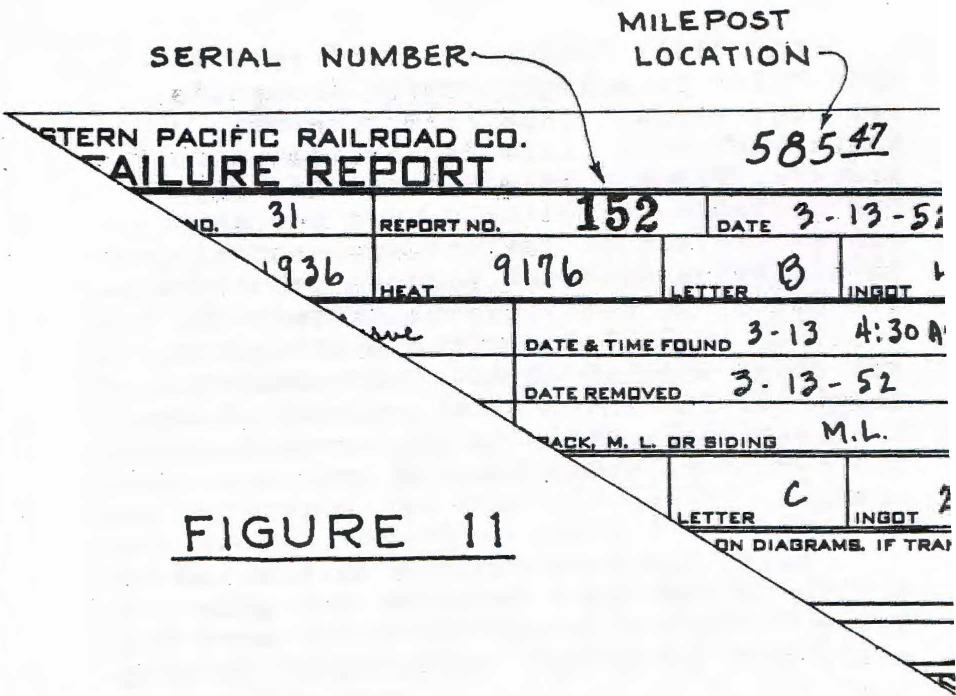


FIGURE 11

RAIL FAILURE RECORD		MILEPOST 585 47
REPORT NO. 152		WT. RAIL 112
DATE FOUND 3-13-52		MILL & YR. A&B 193
FOUND BY W.P.		HEAT NO. 9176
REMARKS:		INGOT 4 / LETTER B
		DESCRIPTION OF FAILURE
		TYPE 30% T.F.
		LOCATION 13' f.e.

FIGURE 12

only two non-serious failures the next three years. Then, in 1947, the trouble began. From then on, we see an upward trend in the number of failures. However, in 1951, the number of failures is still not serious. If the trend continues upward, it is certain we are going to have to do something about it in the next few years. Then again, the trend may level off, or decline. So, as far as the failure record is concerned, we are not worried yet.

Looking up at the tonnage record at the top of the card, we see that at the end of 1951 the rail had carried a total of 323.3 million gross tons, or 323,300,000 gross tons. The estimated life of the rail was only 275 million gross tons, so we have secured more use out of the rail than we had figured. So, despite the fact that the failure record is not bad, we should check up on the rail anyway.

It may be that this rail was better than the average when new, and has been well maintained throughout its life. If that is so, and the rail in track still looks good, we can probably carry it over another few years. Or it may be that the rail looks bad. A quick check with the Division Engineer will tell us which is the case.

When rail has reached its tonnage life, and does not show any failures, a close watch is kept on it for a sudden increase of failures, which is liable to happen in older rail.

RAIL FAILURES PER MILE OF TRACK

MILE 585

YEAR LAID 1936 | MILL A & B | YEAR 1936 | WEIGHT 112

MIL.G.T.	6.2	13.0	11.2	12.3	13.7	17.9	21.6	24.5	26.3	25.9	24.5	24.1	24.8	24.0	26.5	26.8	
		19.2	30.4	42.7	56.4	74.3	95.9	120.4	146.7	172.6	197.1	221.2	246.0	270.0	296.5	323.3	
FAILURES																81	
															56	02	
														14	24	32	
									11		18	14		63	16	46	47
YEAR	1936				1940				1944		1946	1947		1949	1950	1951	1952

FIGURE 13

It will be seen that these records are flexible and cannot by themselves be used to decide whether rail should be replaced. They are a guide and aid to the persons responsible for initiating a rail change program, and are used in conjunction with the judgment of Division maintenance people as to when rail should be replaced. They also form the basis for statistics which will be presented to the Board of Directors, with a request for authority to buy new rail.

Before filing the Rail Failure Report away, the engineer plots the failure in one more place. He looks up the "Rail Heat Record" card which we read about in the first chapter. Let us say the card looked like Figure 14 after he made his entry.

In addition to giving us a story of the rolling of the heat, the card now gives us a record of the fifteen years of its life in track. We see a total of four serious failures. (Here again the boxes are colored yellow for transverse fissures, compound fissures, and detail fractures). Considering that any heat with less than ten yellow failures is considered OK, this heat does not look bad. The three non-serious failures are nothing to worry about, especially since they are well scattered throughout the heat. The only note of concern is that the three fissures in Ingots 2, 3, and 4 are clustered closely, indicating a vague possibility that these three ingots may have had some recurring defect,

RAIL HEAT RECORD

HEAT NO. 9176 | WT. RAIL 112

P. O. NO. 10468-P-1468 8-6-35 | TONS 10460 | MILL A. & B. | YEAR 1936

DROP TEST AND NICK & BREAK TEST

ELONGATION BY INCHES .06 | .07 | .07 | .08 | .07 | .06 TOTAL .41

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
BLOWS		1								5												1	
SET		.65								.75												.75	
FRACT.																							
N. & B.	K	K	K	K	P	K	K	K	K	K	K	K	K	K	P	K	K	K	K	K	K	K	
A					K					30'B	35'B				30'P		S.W. 12-1-50 581$^{\underline{36}}$						
B				30% T.F. 3-13-52 585$^{\underline{47}}$	#2C																		
C		40% T.F. 8-6-49 585$^{\underline{94}}$										#2C	80% T.F. 1-6-49 584$^{\underline{40}}$					/// C					
D			20% C.F. 8-1-47 583$^{\underline{13}}$									#2C											
E		/// D	H.S.H. 7-7-50 585$^{\underline{16}}$													V.S.H. 8-16-44 583$^{\underline{17}}$						#2C	
F		/// D																					

TOTAL RAILS ACCEPTED 129 | REMARKS:

(FIGURE 14)

but we would need more evidence before we worry much about it.

In this manner, the Engineering Department has the life stories of about 3,000 heats ready for immediate reference.

The engineer then looks up the heat record card for the rail that was used to replace the broken rail, to make sure that it came from a good heat.

The failure report is then filed away.

Once in a while, a heat record card will show an abnormal number of failures. As a general rule, any heat that has had ten per cent of its rails involved in serious failures is considered unfit for service. The heat is then condemned. This "condemnation" is an unpleasant task for all concerned, as all the rails remaining in the heat must be found and removed from the track. The cost of this operation is considerable. The manufacturer of the rail is notified and usually a thorough investigation is made in an effort to determine why the heat did not give its expected service.

In a few years, heat condemnation will become a thing of the past. As control cooled rails replace the older rails, transverse fissures are becoming more scarce. All heat condemnations in the past have been due to transverse fissures.

The Engineering Department now processes about 250 rail failures each year. Of these, the great majority are non-serious failures, and most of the remainder are transverse defects which are found by the rail detector cars before they cause trouble. Not all failures are due to faulty rails. Most failures within the joint bars are due to some fault in the track structure, and not to a weakness of the steel.

All in all, when one considers the number of rails in service on the main lines, (over a quarter of a million of them) and the beating they take every day, year after year, Western Pacific has a remarkable safety record with respect to rail failures. This is primarily due to prompt detection and replacement by track maintenance forces, when a failure does occur. The rail failure records, however, play their part behind the scenes, in holding to a minimum the number of failures that have to be found.

Office of the Chief Engineer,
The Western Pacific Railroad Company,
San Francisco, California.
April 17, 1952.