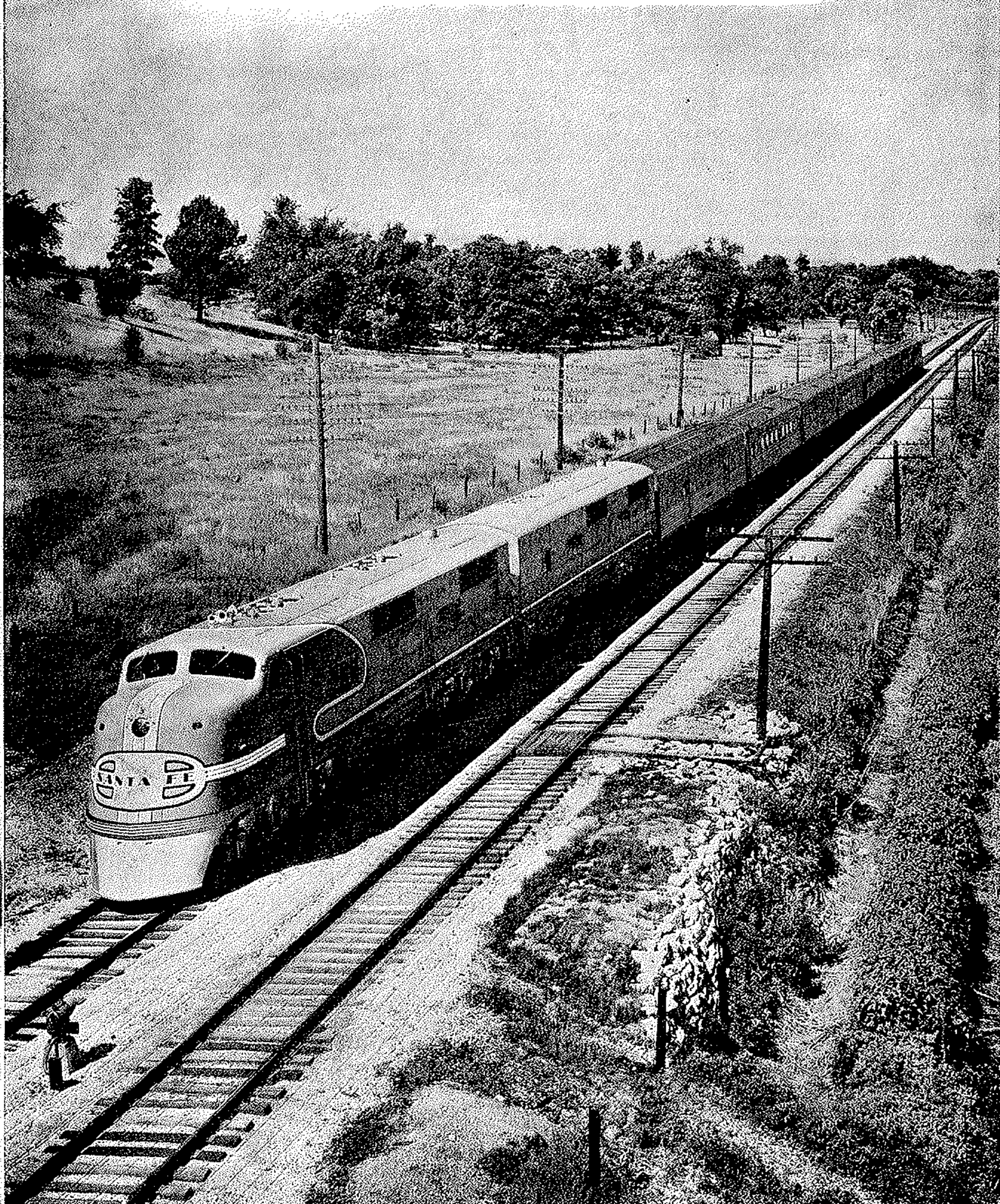
The (No. 5)

The Santa Fe Today



The Santa Fe Today—No. 5

Explanatory note: Expansion of the Santa Fe from a small Kansas enterprise into a vast transcontinental transportation system has brought about many changes in its operations. This article is the **fifth** in a series to explain the workings of this modern railroad plant with its shops, yards, offices and other physical properties which go to make up the Santa Fe today. These articles have been prepared by Leo J. Martin of the public relations department with the co-operation of the various department heads and the editors of The Santa Fe Magazine. The remaining articles in the series will be published and distributed from time to time until all departments of the railroad have been included.

Employees are urged to retain this pamphlet and all others in the series so that at the conclusion they may have a complete story of The Santa Fe Today.

The Santa Fe Today

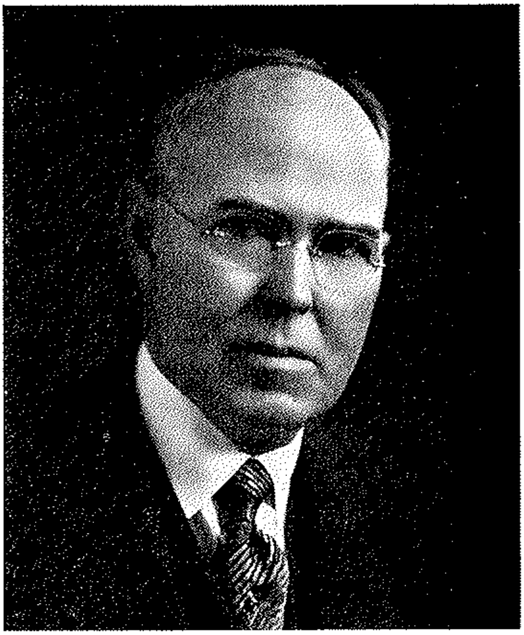
The Engineering Department

THE construction, maintenance and improvement of Santa Fe tracks, signals, bridges, tunnels, depots, shops, roadway facilities and buildings, all civil and signal engineering matters, tie and timber treating facilities and methods, and valuation proceedings, are under the general supervision of G. W. Harris, chief engineer system, Chicago, head of the Santa Fe's engineering department.

All Santa Fe civil and signal engineering practices conform with rules and regulations of the Interstate Commerce Commission, and of state, county and municipal regulatory bodies. Engineering department officers are prominently identified with various committees within the Association of American Railroads, American Railway Engineering Association, American Wood Preservers' Association, American Society of Civil Engineers, and other groups.

The functions of a railway engineer are those of a designer, a supervisor, a constructor, an investigator and an advisor. He must advise in regard to the feasibility of a proposed project, the cost, and the results to be accomplished. He must develop ideas and elaborate plans, consider and prescribe methods and manner of construction, superintend the work that it be properly constructed, and, after completion, see that the project fulfills the functions for which it has been designed.

Santa Fe locating and construction engineers participated in the development of much of the Southwest. When the Santa Fe raced across Kansas in 1872, building the line from Newton to the Colorado line, 285 miles, in eight months; then in 1887, the line from Kansas City to Chicago, 450 miles, in eleven months, with previous spectacular crossings of Raton Pass and Glorieta Pass, and the extension of the Santa Fe to the Pacific Ocean, the engineering department earned undying fame. Hundreds of miles of that territory lay through uninhabited and little explored prairie, mountain, plateau and desert country.



G. W. Harris, chief engineer system, with headquarters in Chicago.

Through the years, with fullest use of men and materials, the engineering department has produced the roadways and structures we identify today as the Santa Fe and of which we are rightfully proud.

The Santa Fe's physical plant begins with its right of way—the land on which Santa Fe rails are laid. Such land was acquired in varying widths parallel with the center line, sufficiently wide to permit drainage facilities, signals, towers, switches, bridge abutments, telegraph and telephone lines, sidings or passing tracks, telltales, buildings and other needs. The right of way is fenced where necessary for protective and safety reasons. Signposts, mail cranes, cattle guards, pipe lines, rail racks, crossing gates, stock chutes, snow fences and other facilities may be placed within right of way boundaries.

The Santa Fe has in addition extensive land areas called "yards" which are further designated as: Freight classification or terminal yards, used in making up and breaking up freight trains; freight depot and team track yards, to facilitate loading and unloading of freight; passenger car yards, where such cars are cleaned, provisioned, and otherwise serviced preparatory to being assembled in trains; storage yards, for all types of cars not in service or awaiting repairs; shop yards, in conjunction with shop facilities under roof, where outdoor repairs are made.

The Santa Fe's largest consolidation yards are located at Corwith, Argentine, Belen and Barstow. At terminal or division points as well as at populated communities, sizable yards facilitate freight traffic and train handling. Other land areas are utilized by the store department.

The Santa Fe, and all railways, acquire certain lands paralleling their right of way in order that they may properly handle their present and anticipated operations. Such lands provide for the expansion of industries served by the Santa Fe and for the location of new industries.

Santa Fe buildings include general office buildings (Topeka, Galveston, Amarillo and Los Angeles), housing executive offices of departments within the Santa Fe's organizational structure; and leased quarters in private building (Chicago) housing executive offices. General executive procedures are conducted from those offices. Such buildings, where constructed by the Santa Fe, are among the most expansive and well-appointed in the community. Roundhouses, power plants, various locomotive and car maintenance buildings at division and other points, and acres of shop buildings at Topeka, San Bernardino, Barstow, Albuquerque and Cleburne, comprise the Santa Fe's system-wide shop facilities.

Other Santa Fe buildings include depots, warehouses, reading rooms for trainmen, Harvey hotels and lunch rooms, yard offices, wharves and docks, and various store houses. Water and oil storage tanks and cranes, pumping plants, wells and reservoirs, coal chutes, sand houses, material, tool and scale houses, stockyards and living quarters for station and section forces, are located on or as near the right of way as conditions permit or justify.

Santa Fe depots parallel the main tracks to permit ease of access to passenger trains and to facilitate the handling of mail, express and baggage. Depot facilities vary, depending on the size of the community and volume of business handled. Small main line and branch line stations have combination passenger and freight depots consisting of a single building with waiting room, freight and baggage room, and ticket office with a bay for the telegraph operator. A loading platform may be attached to the building.

At populated points, separate passenger and freight facilities are provided. Depots at large terminals, Chicago, Kansas City, Los Angeles, and at other points, commonly are used by two or more or by all the railways serving those communities. Operation and maintenance of those depots are joint responsibilities. In its broad operations, the Santa Fe has numerous joint contracts or operating agreements with other railways. That includes use of tracks and

CHIEF ENGINEER'S ASSISTANTS WITH OFFICES IN CHICAGO

L. H. Powell, asst. to chief engineer system.

R. A. Van Ness, bridge engineer system.

C. H. Sandberg, asst. bridge engineer system.

right of way facilities. In some instances, the Santa Fe owns the trackage; in others, the facility is owned by another railway.

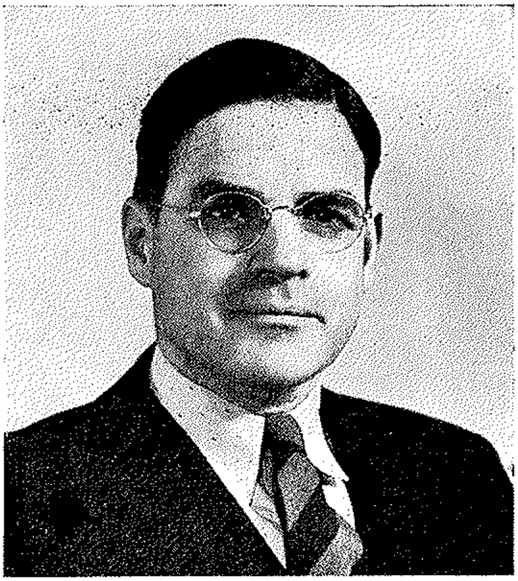
The Santa Fe has a grand total of 21,176 miles of track. That figure, which varies slightly each year, includes 13,084 operated miles, 1,937 miles of second main track, 54 miles of third and fourth main track, and 6,101 miles of yard tracks and sidings.

Exclusive of Santa Fe span-type bridges, there are an estimated 27,300 openings under Santa Fe tracks—concrete and stone boxes, treated timber boxes, concrete and stone arches, concrete, steel and iron pipe culverts. When possible it is good railway practice to shorten span-type bridges or eliminate them entirely by substitution of a type of opening which permits a fill to be placed. Arch, box and pipe culverts are an important aid in attaining that objective.

Santa Fe bridges span canyons and declivities and some of the nation's largest rivers. The approximate lengths of the various span types of Santa Fe bridges are:

Type of bridge	Linear Single track Feet	Miles
Structural steel	297,390	56.3
Steel T-rail	46,156	8.7
Concrete slab	8,844	1.7
Timber trestle	802,542	152.0
Totals	1,154,932	218.7

Detailed study and preparation precedes the construction of a Santa Fe bridge. All bridges are vitally essential to the safe and expeditious movement of traffic. Studies extend to motive power and equipment as the load to be borne by a bridge is of prime importance in determining the type and character of bridge to be erected. In turn, new rolling equipment must be adaptable to present bridge structures, particularly to major permanent bridges; otherwise extensive alterations would be necessary.



Tom A. Blair, assistant chief engineer system, with headquarters in Chicago.

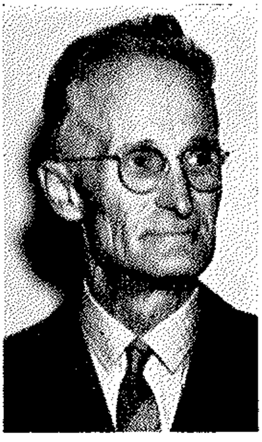
In noting the important features and the history of major Santa Fe bridges, the engineering department's task of renewing original or existing facilities is emphasized. The largest Santa Fe bridges are:

Illinois River Bridge: Two miles east of Chillicothe, Ill. The original structure, built in 1887, was a single track through truss span bridge with a draw span to provide

Charles O. Coverly, architect system.

E. G. Allen, special engineer.

F. S. Hewes, office engineer.



J. R. Rushmer, roadway engineer.




GRAND DIVISION CHIEF ENGINEERS, left to right, F. D. Kinnie, Eastern Lines, Topeka; J. A. Noble, Western Lines, Amarillo; M. C. Blanchard, Coast Lines, Los Angeles; W. H. Rochester, Gulf Lines, Galveston.

for boat traffic. The present double track bridge, 1,695 feet long, was built in 1931. It consists of deck girder, deck truss, and through truss spans. The tracks are on a high grade line, the main channel being spanned by a fixed through truss span 440 feet long. This is the longest simple span on the Santa Fe system lines.

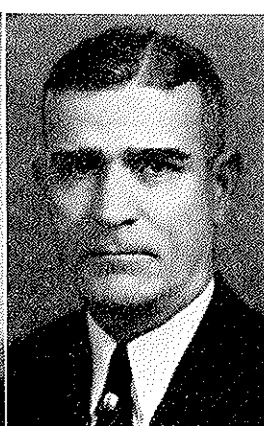
Mississippi River Bridge: At Fort Madison, Ia. Original structure, built in 1887, was a single track through truss span bridge with a draw span to provide for boat traffic. There was a timber trestle approach on the east end. Highway traffic was carried by a roadway at each side of the truss spans and portion of the trestle approach, with a two lane highway trestle approach on the downstream side of the remaining portion of the east approach railway trestle.

Present double track railroad and highway bridge, length 3,347 feet, was completed in 1927. It consists of deck girder and through truss spans with a draw span to provide for boat traffic. The highway is carried from each end of the bridge on through girder spans on an ascending grade to the ends of the truss span portion of the bridge where it swings over the tracks into the truss spans and on a deck above the railway tracks. The tracks are on a low grade line. The draw span is 525 feet long and is the longest draw span in the world.

Missouri River Bridge: At Sibley, Mo. Original structure, built in 1887, was a single track bridge consisting of deck girders on steel towers, and deck truss and through truss spans, the track being carried on a high grade line. The steel spans were

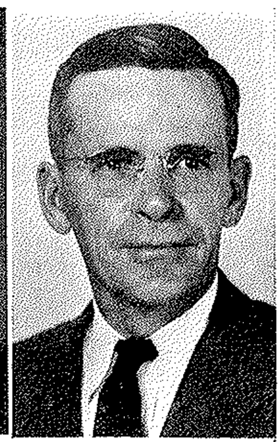
D I S T R I C T

R. D. Pierson
Regional engineer
Los Angeles



F. Helm
Eastern District
Topeka

W. A. Kingman
Western District
Topeka



W. R. Rees
Northern District
La Junta

replaced in 1914 by ones of heavier design, the original truss span piers being revamped to take the new spans. The present structure consists of deck girder spans on steel towers, and deck and through truss spans. There are gauntlet tracks on the present bridge. The Missouri River Bridge, 4,057 feet long, is considered the most picturesque of all Santa Fe bridges.

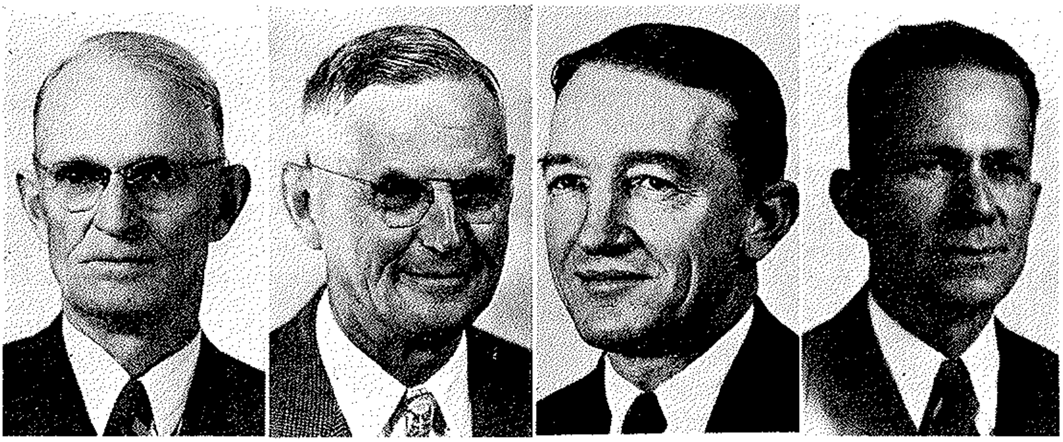
Canyon Diablo Bridge: Over Canyon Diablo, 26 miles west of Winslow. Original structure, built in 1881, was a single track steel viaduct with deck girders and truss spans on bents and towers. Renewed in 1900 as a single track viaduct, consisting of deck girders on towers. Total length 531 feet. In 1913 gauntlet tracks were placed across the bridge when second track was built through this territory. Renewal of this bridge has just been completed, being a double track structure, 300-foot steel deck arch with 120-foot simple deck truss span on each end having the contour of a half arch, total length 544 feet, face to face of parapets. This is the highest bridge on the Santa Fe system, distance from base of rail of the new bridge to the bottom of the canyon being 222 feet.

Colorado River Bridge: At Topock, Ariz., 11 miles east of Needles. The Santa Fe has had three bridges across the Colorado River in the Needles-Topock area since 1883. The present double track bridge was completed in 1945. It has the deepest pneumatic pier constructed under water in the United States, extending to a depth of 125 feet below the water level at time of construction. The bridge has three 350-foot deck truss spans, a 50-foot beam span and a 100-foot deck girder span on the east end and three 100-foot deck girder spans on the west end. Total length of the bridge is 1,506 feet, 9 inches. Both abutments and the seven piers consist of a shaft supported on two cylinders each, the cylinders landing on and keyed into solid rock. The new bridge replaced the celebrated Red Rock Bridge placed in service on May 10, 1890. Red Rock Bridge, located a few hundred feet downstream from the new bridge, was at the time of construction, and for many years, the largest cantilever railway bridge in the United States.

Canadian River Bridge: Two miles east of Canadian, Tex. The original structure, built during the construction of the Southern Kansas of Texas Railway in 1887 to 1889, was a timber pile trestle bridge. The present bridge, 2,441 feet in length, consists of four 260-foot through truss spans erected in 1908, and six 115-foot deck girder spans erected on each end in 1925.

Masonry and concrete work on right of way includes tunnels, retaining walls, foundations, piers, headwalls, water columns and various pits, signal bridges, arches, abutments and other constructions. The Santa Fe has few tunnels throughout its system lines. There are no tunnels on the Eastern and Gulf lines or on the Southern District of the Western Lines. In all, there are two tunnels on the Northern District of the Western Lines (summit of Raton Pass), and ten on the Coast Lines. Tunnels may be of timber, brick, masonry, concrete or rock lining. The location, length and grade of Santa Fe tunnels follows:

E N G I N E E R S



J. W. Walter, Southern District, Amarillo — R. E. Chambers, Coast Lines, Los Angeles — H. E. Wilson, Coast Lines, Los Angeles — W. T. Donoho, Gulf Lines, Galveston

Tunnel	Length in feet
Raton—eastbound	2,040.6
Raton—westbound	2,789.3
Johnson Canyon	396.8
Nelson Canyon	414,1
Mile 23, Clarkdale Branch	568.0
Mile 56, Parker Branch	240.7
Cajon No. 1—eastbound	379.0
Cajon No. 2—eastbound	467.5
No. 1, Vine Hill, Valley Division	1,229.9
No. 2, Muir, Valley Division	299.9
No. 3, Franklin, Valley Division	5,595.6
No. 5, Richmond, San Francisco Terminal Division	859.5

The Santa Fe's original transcontinental route, Chicago to the Pacific (today's northern route), experiences a continuous rise west of Newton. Beyond Trinidad, the grade ascends Raton Mountain, a lateral spur of the Rocky Mountains, a rise of 1,632 feet in fifteen miles at a ruling grade of 3½ per cent. The highest point on the Santa Fe system lines, Raton summit, 7,622 feet, is the crest of that grade. The grade breaks at the west end of both tunnels at approximately 7,587 feet. A ruling grade of 3.3 per cent was located west of Raton tunnels to Springer, altitude 5,832 feet. The line then rises to 6,401 feet at Las Vegas, and over the southern end of the main chain of the Rocky Mountains to Glorieta, 7,437 feet.

The Santa Fe's builders originally planned to follow the thirty-seventh parallel; beyond Las Vegas, however, the line was deflected southward to find suitable grades for crossing the range, as west and northwest of Las Vegas the lowest pass exceeds 10,000 feet.

A long, steep climb was located west of Glorieta to Glorieta Pass. The approach from the east, however, is much less difficult and the grade less prolonged than the 3 per cent ruling attained on the western side. After a leisurely descent to Albuquerque, altitude 4,953 feet, the line begins the long, steady climb to the Continental Divide. The line here is located on a very moderate grade, about thirty-two feet to the mile—the Colorado Plateau area of New Mexico. The Continental Divide lies in a broad east-west depression known as Campbell's Pass. The summit, 7,248 feet, reached just west of Gonzales station, is 374 feet lower than Raton Pass.

The line then follows Arizona's northern plateau country, crossing the Arizona Divide, altitude 7,311 feet, at Riordan west of Flagstaff, over moderate grades, and dropping to near sea level at Needles on the Colorado River. Crossing the Mojave Desert, the line enters southern California through Cajon Pass, a gap between the San Bernardino and San Gabriel mountain ranges. Cajon Pass has some 3 per cent grade on its western slope; west to east traffic, however, is carried over a ruling 2.2 grade, as is all traffic over the Tehachapis to Bakersfield and the San Joaquin Valley.

An important feature of the Santa Fe's transcontinental route via Raton and Albuquerque is that the route penetrates high mountainous country without having to ascend to heights greater than 7,622 feet. The southern route, via Amarillo and Clovis, attains an altitude of 6,492 feet at Mountainair, N. M. The route differs from the northern line in that its rise westward from Newton is moderate to Fort Sumner. From the latter point to Mountainair, a distance of 139 miles, it rises 2,428 feet at a ruling grade of 0.6 per cent, then drops 1,686 feet in the 41 miles to Belen at a ruling grade of 1.25 per cent.

In choosing a route and in building a railway, consideration is given the following: Reconnoissance survey of the area to be traversed, preliminary survey, location survey, and acquisition of the right of way. That includes a detailed study of the general topography of the area as well as the cost of constructing, operating and maintaining the proposed line. Important factors to be considered are the volume of traffic to be carried over the line, maximum train loads, tonnage ratings, minor and ruling grades, need of pusher or helper service; the distance involved, cost of additional motive power to handle traffic, effect on traffic by ruling grades; curvature in relation to compensation, resistance and speed; rise and fall—ruling grades, time requirements, balance of grades for unequal traffic (excess in either direction), maximum length of trains, acceleration; laws of accelerated motion as applied to virtual and other grades, velocity head, kinetic energy of trains; grade line, profile, cross section, yardage, mass diagram; drainage, in relation to need for and size of waterway openings, culverts, trestles (open and ballast deck), arches, viaducts, plate girders, trusses.

All those factors and others (each section has its peculiar problems) must be considered in establishing the grades, descending and ascending, and in determining the location and extent of bridges, underpasses, cuts, fills, embankments, tunnels, tangents and curves. The subgrade is then prepared and cuts and fills of standard width are constructed. Ties, rails and ballast are laid

DIVISION ENGINEERS

W. E. Axcell
Missouri

T. H. McKibben
Chgo. Term. and Ill.

M. W. Bell
Kansas City

R. H. Beeder
Eastern

A. F. Ewert
Southern Kansas

H. J. Moore
Middle

H. L. Miller
Oklahoma

A. B. Truman
Western

O. F. Arthur
Colorado

W. R. Baker
New Mexico

R. J. Gatewood
Panhandle

J. B. Raymond
Plains

N. D. Bloom
Pecos

J. G. West
Slaton

W. B. Darling
Albuquerque

E. L. McDonald
Arizona

L. E. Smith
Los Angeles

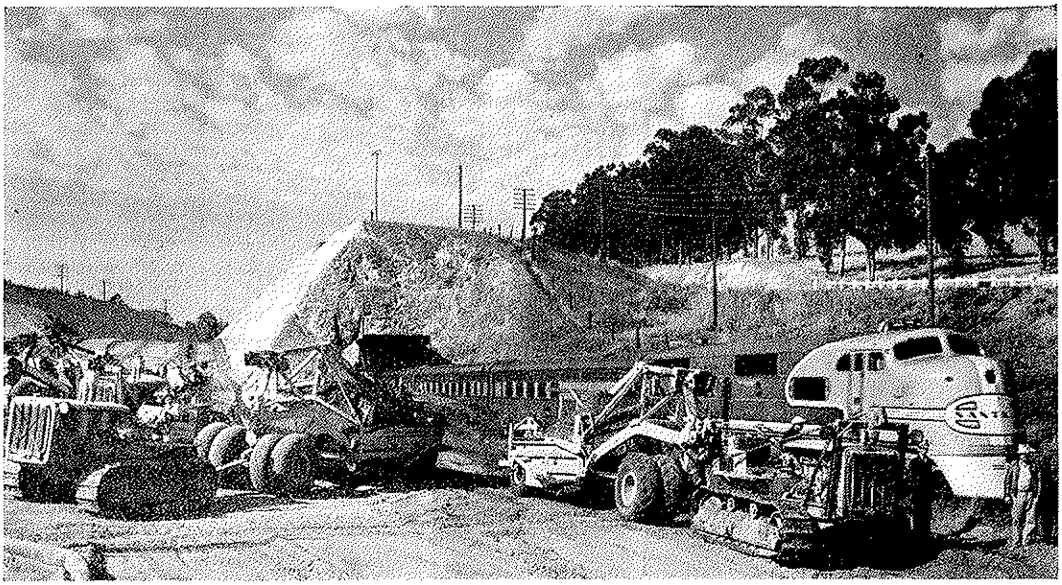
O. R. West
Valley

H. R. Hart
San Fran. Term.

S. W. Brady
Northern

W. Y. Ware
Southern

R. A. Wood
Gulf



Improvement resulting in abandonment of tunnel near Pinole, Cal.

and signals and other necessary facilities installed.

Grades are expressed in percentages. A level track is zero grade; a vertical climb of two feet in 100 feet of track is a two per cent grade or, expressed in terms of mileage, is a rise of 105.6 feet per mile. Vertical curves are used to round off intersecting grades so that smooth passage may be provided.

On a railway the length of the Santa Fe there are unending maintenance problems. Most present-day Santa Fe construction consists of track extensions (additional second and third main line track), the elimination or separation of highway grade crossings by the construction of underpasses or overhead bridges, drainage work, curve reduction and other alignment changes, relaying rail, and the replacing and strengthening of bridges.

Grade separation work involves matters of track elevation or depression, retaining walls, abutments and piers and clearances. World War II necessitated many additional yards, tracks, roadway facilities and buildings.

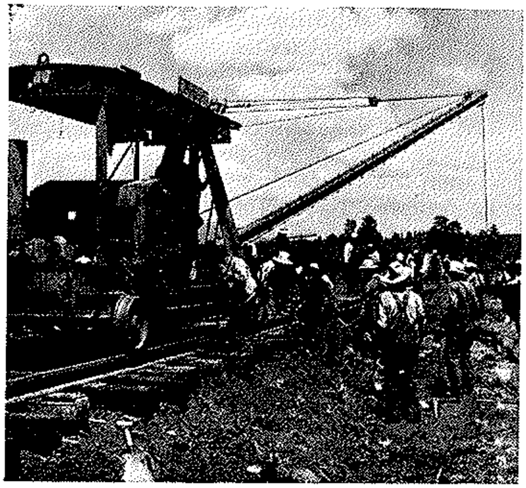
When the Santa Fe began construction at Topeka in 1868, its goal was Santa Fe, N. M. Reaching Santa Fe, the line was extended across New Mexico, Arizona and California. It reached northward to Denver, southward to Galveston and El Paso, and eastward to Chicago. The line then penetrated California's long Central Valley to San Francisco Bay.

A considerable portion of that mileage was acquired by purchase and agreement; Santa Fe engineers, however, have so completely changed and improved it that from an engineering standpoint it is strictly Santa Fe.

Most American railways, at the start of construction, knew where they were going. They were not always certain, however, how they were going to get there. The alignment of a railway depends on the physical features of the country and the funds which are available for overcoming natural obstacles. The engineer must skillfully interpret all natural conditions in the light of construction, operation and maintenance costs and practices.

Santa Fe engineers did not have unlimited funds. They located the best line they could (it evoked the admiration of early-day railway builders), overcoming natural obstacles, and abnormal conditions imposed by rainfall, snow, floods, wind and water erosion, a lack of water and of essential supplies. As the years passed, operating demands necessitated changes in the alignment of most of those tracks.

The railway engineer continually is confronted with problems of feasibility and costs; whether to locate or relocate portions of the line through, around, over or under existing obstacles. Changes in locomotive



GRADING OPERATIONS

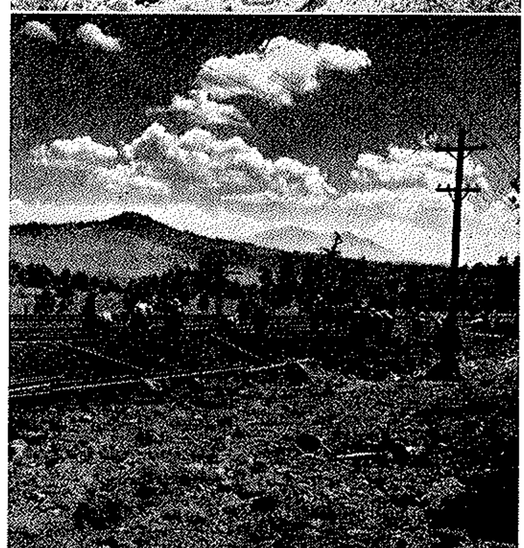
Upper left—Track laying operation: Crane swinging rail into place.

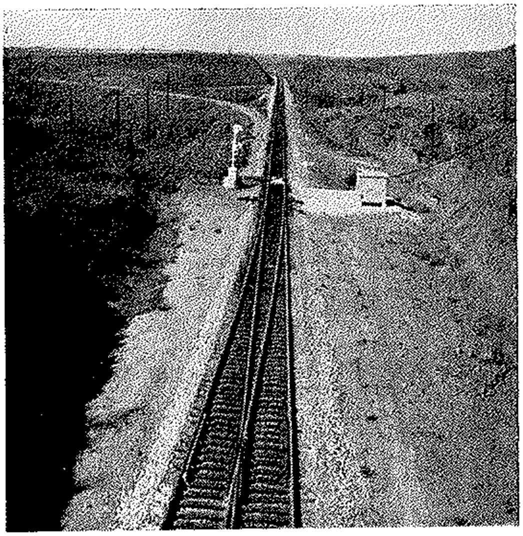
Upper right—Laying rail: Tie adzing machine in foreground.

Center—Trackmen inserting new ties.

Lower left—Surfacing track using pneumatic tampers.

Lower right—Workmen laying turnout switch.





Line change at Quinlan, Okla., showing west end of passing track. Note old track alignment curving to left.

design and capacity as well as improvements in all types of rolling equipment have encouraged and necessitated like changes and improvements in roadway, track and facilities. Since 1935, the Santa Fe has pursued a broad program of curve reduction and elimination, increasing the length of tangents (straight or high-speed track), which in turn has permitted faster schedules and reduced operating and maintenance costs.

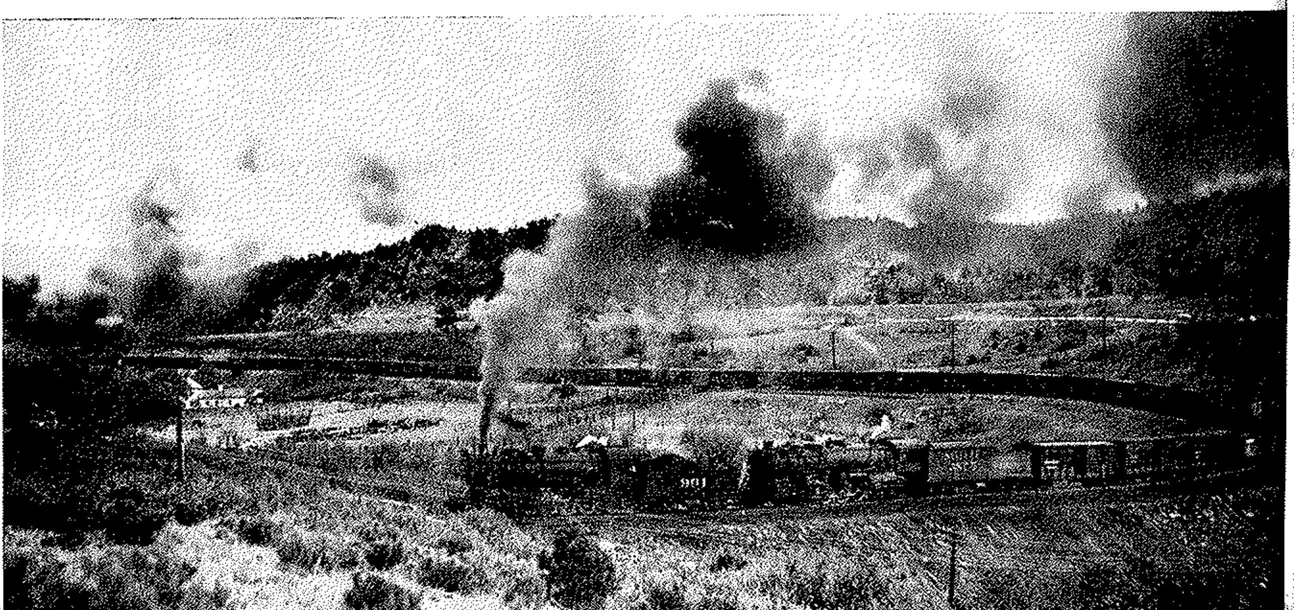
The chief engineer system and assistant chief engineer system are located at Chicago from which point they direct the engineering activities of the Santa Fe system lines. The chief engineer system reports directly to the president on construction and to the vice-president in charge of operation on matters relating to maintenance of way and structures. The chief engineers of the Santa Fe's four grand divisions, under the direction of the chief engineer system, are located as follows: Eastern Lines, Topeka; Western Lines, Amarillo; Gulf Lines, Galveston; Coast Lines, Los Angeles. Each of those chief engineers report directly to his general manager.

Each Santa Fe grand division chief engineer is in direct charge of civil engineering matters on a general manager's territory, assisted by a staff which includes a district engineer or engineers, office engineer, local division engineers, valuation engineer, architect, right of way agent, water service and steam heat engineer, locating and construction engineers, and a staff of engineers and assistants. In addition, the Coast Lines has a regional engineer.

The staff of the chief engineer system, Chicago, includes the following, with assistants all versed in their particular duties: assistant chief engineer system, assistant to chief engineer system, bridge engineer system, assistant bridge engineer system, valuation engineer system, architect system, special engineer, office engineer and roadway engineer. In addition, the chief engineer system has on his staff the manager of treating plants system and the signal engineer system, who, with their office forces, are located at Topeka.

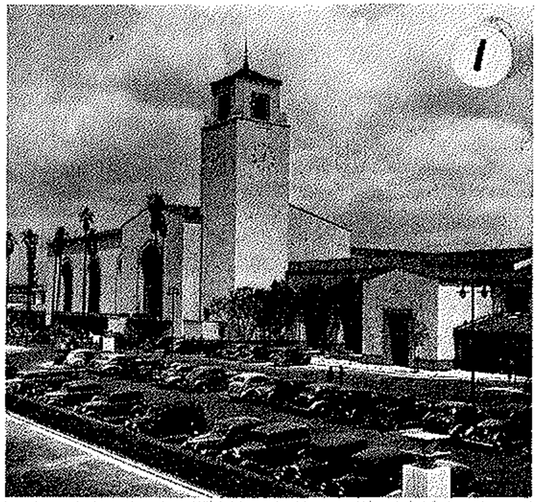
Standard practices as approved by the chief engineer system and the vice-presi-

Ascending grade. Two Santa Fe 2-10-2s, on head end of 60-car freight train going up north side of Raton Pass. Another similar locomotive is helping on rear end. Raton summit, 7,622 feet, is the crest of this grade.



HIGHLIGHTING SANTA FE STATIONS

1. Los Angeles, Cal.
2. San Diego, Cal.
3. Kansas City, Mo.
4. Amarillo, Tex.
5. San Bernardino, Cal.



Santa Fe passenger terminal at San Francisco, Cal., to and from which buses operate in connection with Santa Fe Railway station in Oakland.

dent in charge of operation are contained in the authoritative Chief Engineer System Standard Plans issued to all engineering offices on the system for reference and guidance. Those plans embrace roadway and structures, bridges, buildings, signals and the numerous constructions and installations to be found throughout Santa Fe premises. They represent decades of engineering achievements in meeting problems and insuring uniformity of practices on the Santa Fe system lines.

There are many specialized tasks within the scope of the engineering department which necessitate system handling from the chief engineer's Chicago office. The assistant to chief engineer and staff handle departmental matters in connection with improvements to existing Santa Fe facilities, studies of branch lines, governmental flood control and grade separation projects that involve Santa Fe property, tie and timber matters and other miscellaneous assignments.

The system bridge department is in general charge of timber, concrete and steel structures and standard plans in connection therewith. Structural analysis and design or check of design is made of building foundations, structural frames of buildings, highway bridges, turntables, transfer tables, traveling cranes and derricks, post cranes, sanding towers, tank towers, water tanks, dams, coaling and ash handling facilities, tunnels, concrete inspection pits, concrete reservoirs, concrete and steel pipe, arch and box culverts, rail stresses and locomotive counterbalance.

The latter concerns the placing of metal weights on locomotive driving wheels to balance the revolving weights of the crank pin, main or side rod, and the reciprocating weights of the crosshead, piston and piston rod. Too much weight results in damaging pound on the rail; too little, permits the locomotive to vibrate to an extent it may be seriously damaged. Counterbalancing must insure the least possible damage to track, bridges and locomotives. With increased speeds, the subject of locomotive counterbalance has become a most important operating factor.

In 1946 the Santa Fe acquired electrical instruments for use in determining live load unit stresses in members of older steel bridges. These appliances are operated by the test department in co-operation with the system bridge department. The recorded stresses include the effects of bridge, track and engine conditions.

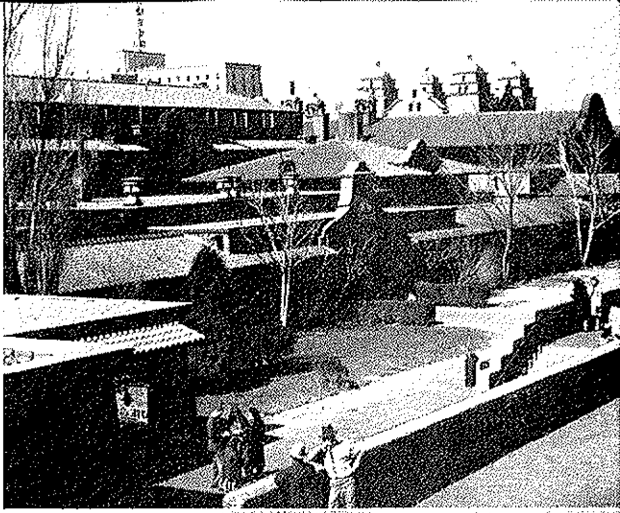
The system architectural department has general supervision of plans, specifications and estimates for buildings on the system lines. Those buildings include passenger stations, freight houses, office buildings, Harvey hotels and shop buildings of various types. Standard plans are developed for section houses, depots, engine houses, bunk houses and other structures. The department collaborates with the various grand division chief engineers and their architectural staffs in matters involving maintenance, repair and modernization of existing buildings; and with the traffic department in the development of new ticket offices, reservation bureaus, and other passenger office facilities.

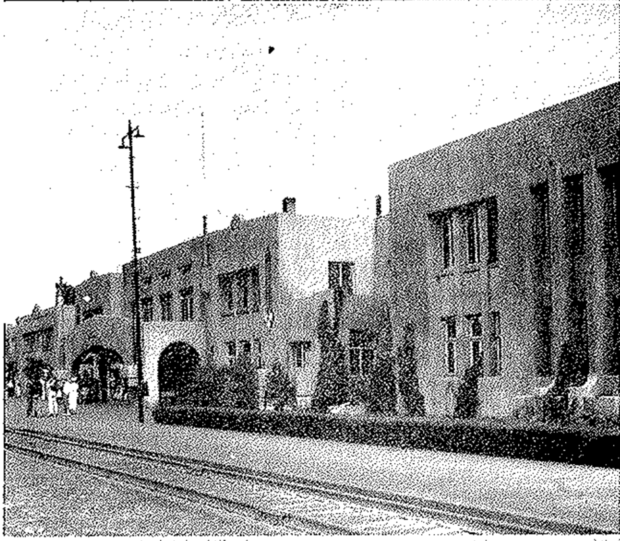
The special engineer, as his title designates, handles studies and prepares reports on important subjects of a special nature, as new passenger and freight terminals, consolidations, and other such matters that may arise.

The office engineer and staff prepare and distribute standard plans and instructions relative to maintenance of way matters—track, rail, roadbed, ballast, fence, frogs and switches, railway and highway crossings; also the scheduling of operations for the Santa Fe's two rail flaw detector cars which move about the system lines. Rail defects, due to service failures or detector car findings, are recorded and classified. All rail heats (eighty to two hundred rails to a heat) are recorded and recommendations are sent to general managers concerning the removal of rails in a heat where the transverse fissure and other defect limit has been reached.

The office engineer and staff handle specifications for new rail, annual rail renewal programs, special reports on rail damaged in track, rail design, studies for improvement of rail sections or manufacture and the recording of all reports rendered by inspectors at mills during manufacture of the rail. That includes study and design of track materials such as frogs, switches, railway crossings, slip switches, adjustable rail braces, joint bars, tie plates, track bolts and spikes and general supervision of their manufacture.

All station and right of way maps as well as all profiles for the Santa Fe system lines are assembled by the office engineer and innumerable maps and profiles are made for special purposes. Prints of annual records received from each grand division chief engineer concerning rail, side tracks, bridges, ballast, buildings, railroad crossings, water service, joint facilities, curves, clearances, detours and fence are assembled and made available for executive and other Santa Fe departmental use. Clearance records concern obstructions which might prohibit the movement of extra high, wide or long shipments and all such proposed movements are studied and reported to the general superintendent of transportation for his approval.

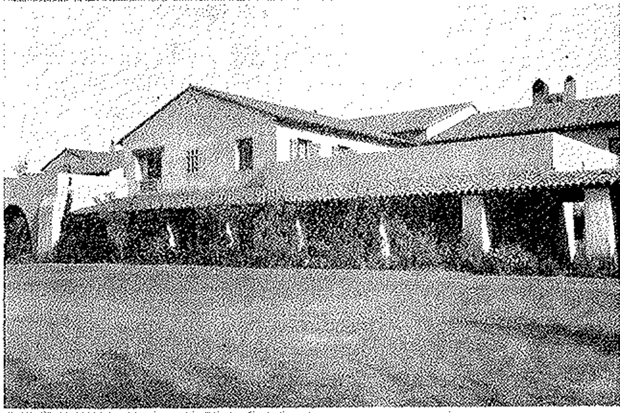




FRED HARVEY HOTELS

At right, top—Alvarado Hotel at Albuquerque.

Second—El Navajo Hotel at Gallup, N. M.



Third—La Posada Hotel at Winslow, Ariz.

Bottom—Fray Marcos Hotel at Williams, Ariz.

Below—An interior view of Fred Harvey restaurant in Dearborn Station, Chicago.

Starting in 1938 the Western Lines carried on experiments for stabilization of blow sand and later experimented on grouting of track and ballast cleaning. The results of the experiments were so beneficial that in 1944 the position of roadway engineer was created and he was placed in charge of all roadway experiments for the system, including track grouting, ballast cleaning, the development of better methods and machinery for surfacing track, rail laying, skeletonizing ballast, weed killing, oiling joints, and other allied matters.

As an outgrowth of the early experiments in grouting, the Santa Fe has undertaken the largest hydraulic pressure grouting program of any railway. Ballast laid on some soils, particularly those containing clay, has a tendency to depress into the subgrade. That permits water to seep into the depression and to remain there, setting up a condition where the roadbed becomes progressively softer and the track so poorly supported that an excessive amount of labor is required to keep the track up to normal condition insofar as safety and riding qualities are concerned.

Many methods have been tried in an effort to stabilize such roadbed by the installation of drains and driving ties or poles at ends of ties to prevent plastic clay from squeezing out.

The Santa Fe has developed a method of pressure grouting which fills these depressions by pumping into them a grout composed of cement, sand and water and a small amount of emulsified asphalt, which displaces the water standing in the ballast and cements the ballast particles into a weak concrete which is thought to have more or less self-healing properties. This process, by filling the voids of the ballast with grout, stops the tendency of plastic clay to flow under pressures exerted by trains moving over the track, and has the effect of stabilizing the roadbed. It likewise increases safety and reduces maintenance costs.

The machinery developed by the Santa Fe for this work consists essentially of a crawler-type tractor, on which is mounted a two-stage air compressor, a grout mixer and a grout pump. The pump is air-driven, its stroke being regulated by a hand lever at the side of the pump. Sufficient water is provided to produce a mixture that will readily penetrate all voids and will be easily handled by the pump and discharge lines. Several manufacturers now sell equipment for track grouting.

The Santa Fe has done much pioneering work in hydraulic pressure grouting, its system roadway engineer being a specialist in that field. Careful records of all factors relating to grouting operations are kept, including descriptions of track conditions, maintenance required before treatment, previous attempts to stabilize roadbed, effect on train operations, and maintenance required since grouting. A total of 450 miles of soft track has been grouted to date.

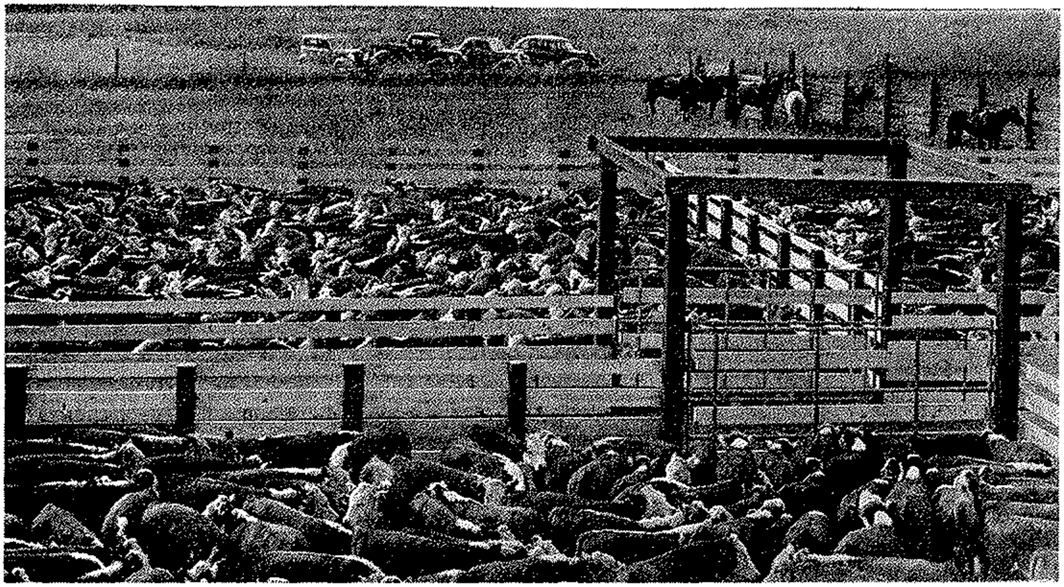
A large shoulder ballast cleaner was designed by the Santa Fe and placed in service on August 1, 1945. This cleaner requires a work train, as it is not self-propelled, and has a capacity under ideal conditions to clean up the ballast on both shoulders of single track at the rate of 2½ miles per hour. This machine cleaned 310 miles of ballast in 1945, and in 1946 cleaned 721 miles. It is usable on single track, and with some penalty in working time on double track. This machine cleans ballast cheaper than by any other known method.

Two intertrack plow cars have been constructed in company shops, these cars being used to plow up the ballast between double tracks and deposit it on a belt that transfers it to the outside shoulder of one of the tracks. This is an operation that was formerly taken care of by a steam ditcher or by hand.

Wherever practicable the roadway engineer works with manufacturers in developing and improving their products. An example of this is the handling of gas unit tampers, with which about half of our main line sections are now equipped. Tampers have been purchased from the three companies that manufacture them, and through co-operation with these companies many improvements have been made in the unit tampers resulting in better performance and lower maintenance cost.

Details concerning Santa Fe signals, timber treating plants, and valuation proceedings, will be outlined in chapters immediately following.

Each grand division chief engineer receives instructions from and reports to the chief engineer system on matters involving standards, and to his general manager on matters involving maintenance and construction of tracks, buildings, bridges, fuel and water and all other facilities. The preparation of plans and estimates covering alterations and major repairs to those facilities, as well as plans and estimates covering new facilities, are responsibilities of the chief engineer who supervises construction, reconstruction, or alteration and the purchase and sale of land and other physical property on the grand division territory.



Loading cattle on the Santa Fe at Nanos, Okla., for shipment to Kansas City. Such scenes are common in the Osage country at the close of the summer grazing season.

Chief engineers also serve on joint depot and terminal committees within their territory.

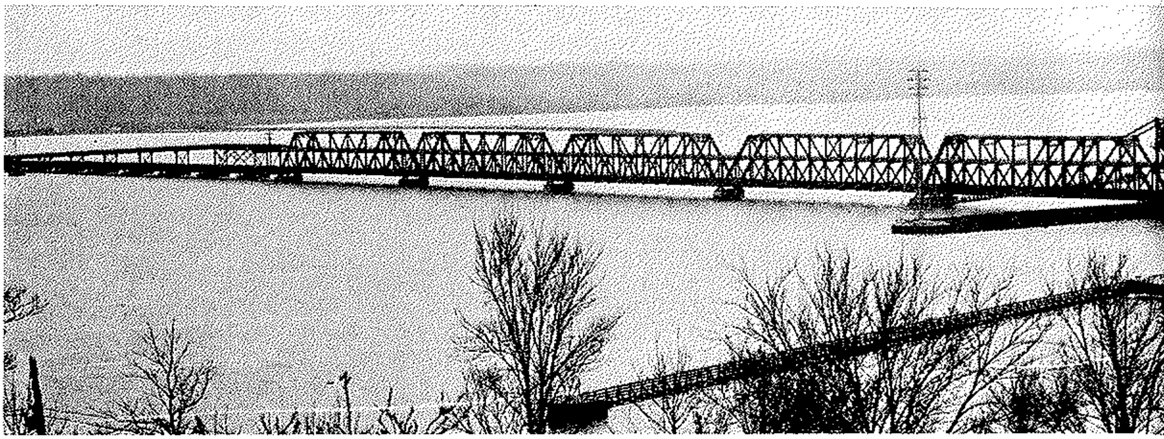
District engineers report to chief engineers in matters of standards and design and to assistant general managers on matters pertaining to maintenance of tracks, roadway, bridges and structures. District engineers field-check track, structure, bridge and other improvements, and assist with organizational plans for carrying out authorized projects. They also assist division engineers in handling drainage matters, damage and right of way claims, and give special attention to trials of new equipment and methods, and frequently are assigned to render reports on special projects under consideration.

Office engineers on grand division territories handle all engineering matters directly under the chief engineers. They handle all correspondence, supervise the preparation and assembling of invitations, plans and specifications for bidding by contractors on proposed Santa Fe improvement and maintenance work, the preparation of contracts after work is awarded, place orders for material furnished by the Santa Fe to contractors, the preparation of vouchers in favor of contractors covering monthly estimates and inspectors' details on construction work being performed under contract.

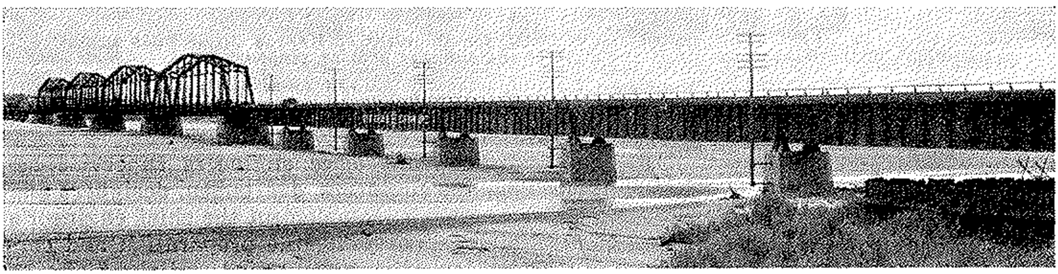
Assistant office engineers supervise assistant engineers, draftsmen, designers and others who complement the chief engineer's staff, supervising the preparation and correction of station ground and right of way maps and records, design of bridge foundations and substructures, preparation of estimates or verification of estimates prepared by other departments, checking leases and contracts (other than construction contracts), the preparation of deeds and bills of sale and annual statements. Plans and estimates covering line changes, curve reduction studies, repairs and strengthening of steel bridges and work programs covering those projects also are supervised.

The chief engineer's steam heat and water service engineer has supervision of design and construction of heating plants for Santa Fe buildings, water facilities and locomotive fuel oil and sanding facilities. Such facilities are designed by engineers under his direction and are constructed under his supervision. He also supervises maintenance of those facilities.

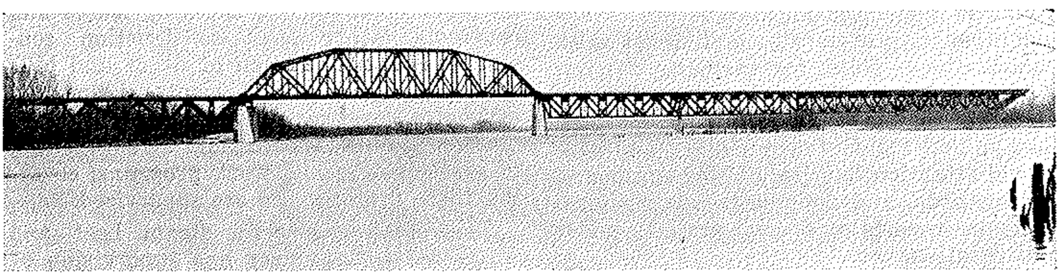
Throughout their broad territories, Santa Fe water service engineers must cope with varying water problems. In the Santa Fe's middlewestern territory, water generally is secured from streams, rivers and wells and the supply is steady. Water sources in the western states are deep wells and dams, and in that arid region the development of



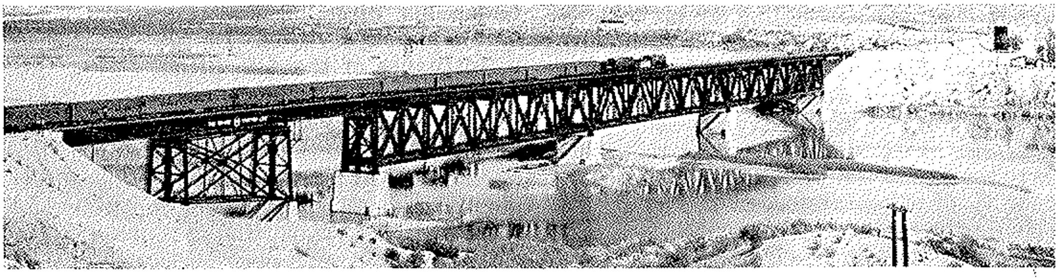
SOME SANTA FE BRIDGES



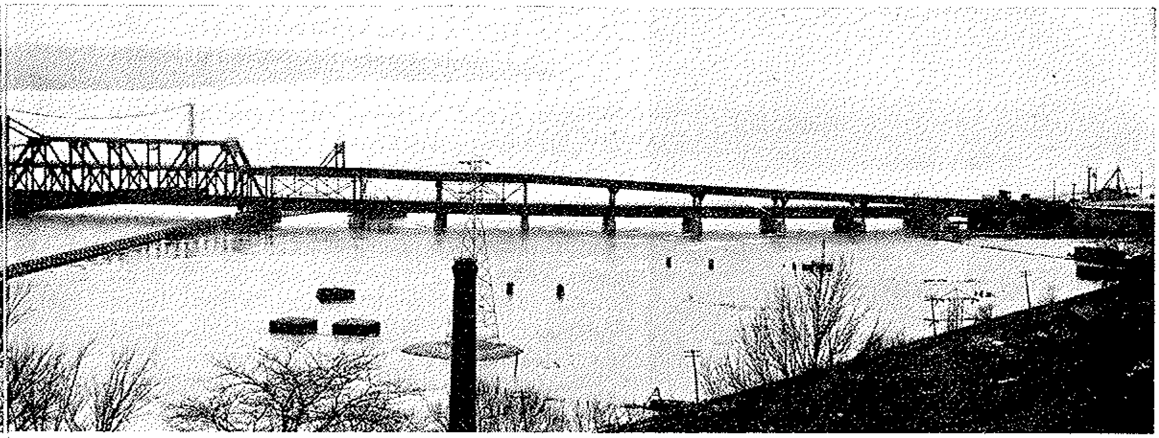
Bridge across Canadian River, two miles east of Canadian, Tex.



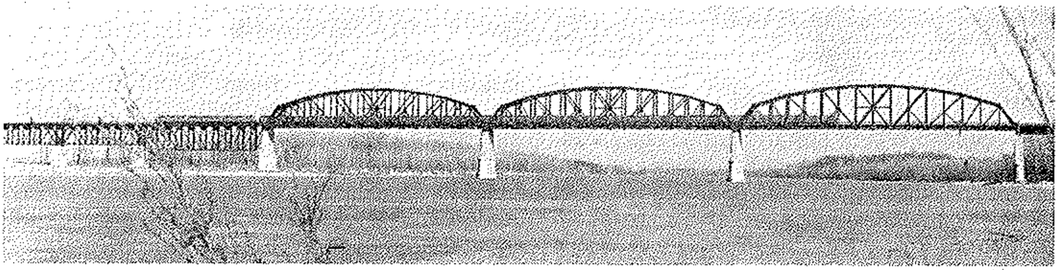
Illinois River Bridge, two miles east of Chillicothe, Ill.



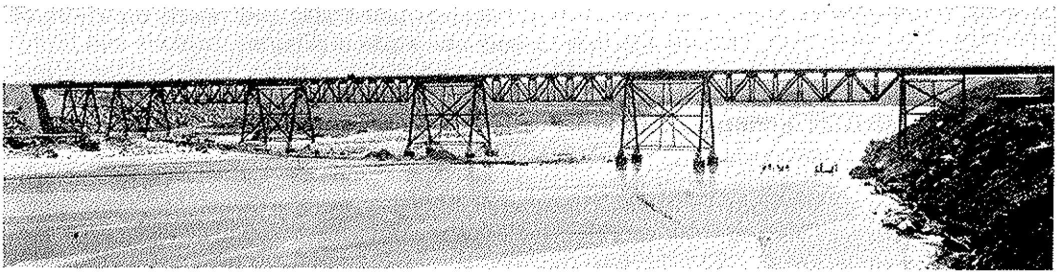
Colorado River Bridge at Topock, Ariz., 11 miles east of Needles.



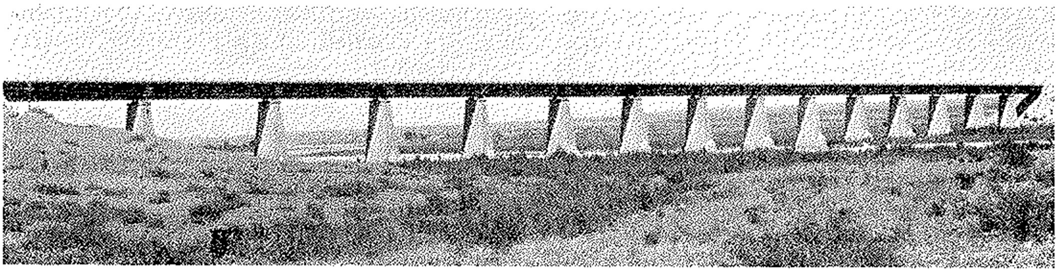
Fort Madison double-deck, or rail and highway, bridge across the Mississippi River.



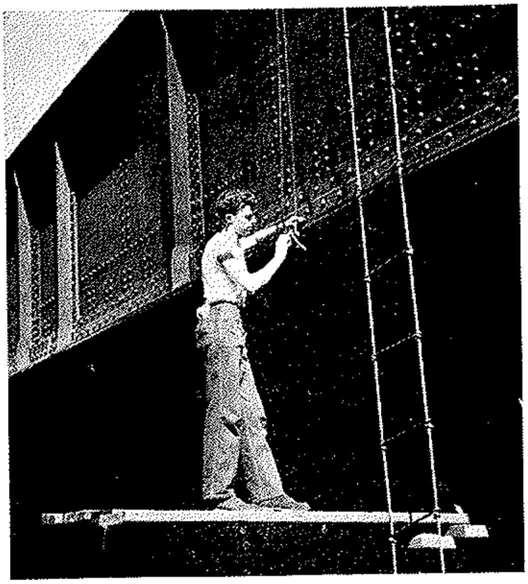
Sibley Bridge over the Missouri River.



Canadian River Bridge, twenty miles north of Amarillo, Tex.



Bridge across Pecos River near Fort Sumner, N. M.



Applying grease to an A-3 strain gauge. The masking tape, lacquer, paraffin and grease are added to make sure no moisture can touch the delicate instruments.

an adequate water supply requires considerable knowledge of ground waters and pumping equipment. In certain plateau areas it is necessary to bring in water in tank cars. Water service crews move about the Santa Fe lines, developing water supplies and plants, including tanks, deep wells, treating plants and water columns. Construction plans and development are supervised by water service engineers, who also supervise construction of fuel oil facilities and maintenance matters in relation to water, fuel oil and heating facilities.

The grand division architect, under the chief engineer, prepares plans, specifications and estimates for new buildings and for repairing, remodeling and modernizing existing buildings. The architect exercises general supervision over construction of new buildings and improvements including painting and decoration. Such plans of a major nature are submitted to the system chief engineer for detailed checking by architect system. Construction of buildings usually is by contract and during construction a building inspector, instructed by the grand division architect, is assigned to the project. The architect also makes periodic visits to the project.

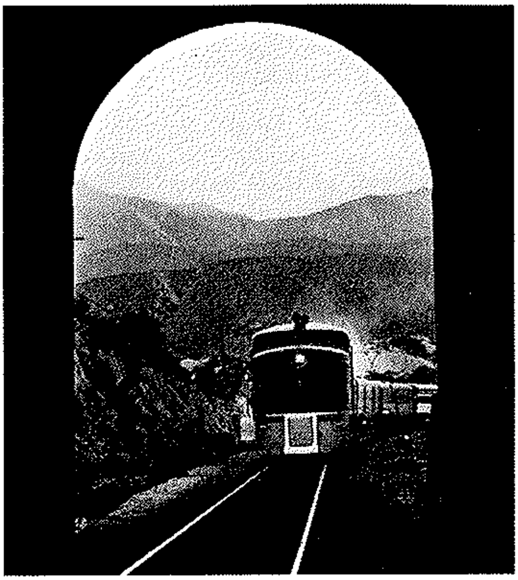
The architect system and grand division architects serve as consultants in the matter of color selection, floor tile patterns and other appointments. Responsibilities include air-conditioning of buildings, selection of lighting fixtures, electric and other advertising signs. Local surroundings greatly influence the design and decoration of Santa Fe buildings.

Each grand division chief engineer has a right of way agent who buys land needed for right of way and other Santa Fe purposes. The right of way agent also sells land no longer needed for railway purposes, maintaining information on current market values of all right of way and other Santa Fe lands which is the basis for rentals on long-term leases and sales prices. Right of way agents have a wide knowledge of land values within their respective territories and an intimate knowledge of Santa Fe lands.

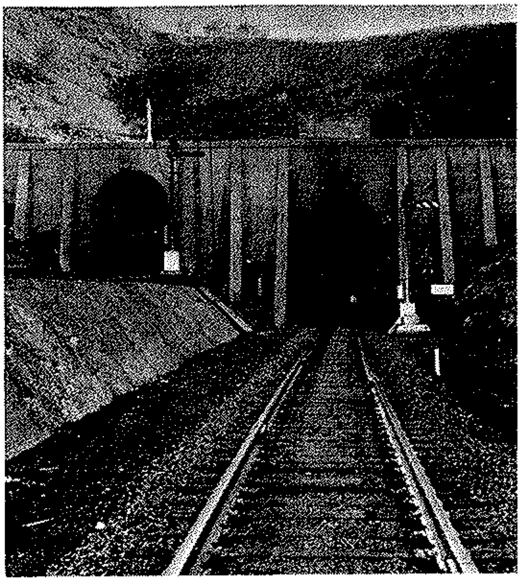
All Santa Fe land transactions require executive approval. Title papers are submitted in final form to Santa Fe attorneys for approval as to form and continuity of title. As a general rule, the description of the property contained in such instruments is written by land draftsmen in the chief engineer's drafting room. Land draftsmen also prepare sketches indicating property the title papers of which must be submitted for executive sanction. Both in the purchase and sale of lands, the right of way agent or his assistant actually contact all parties involved. That often necessitates considerable traveling. Right of way agents also act in a consulting or advisory capacity on numerous matters in which lands are a part of the project.

Maintenance and new work on right of way and station grounds, bridges and buildings and water service, is under the direct supervision of the division engineer, assisted by the roadmaster, general bridge and building and water service foreman, track supervisor, section foreman and others. Industry tracks, easements, franchises, deeds, leases, assessments, city improvements, paving, and other matters also receive the attention of the division engineer. The general duties and responsibilities of roadmaster, general bridge and building and water service foreman, office engineer, transitman, draftsman, rodman and chainman are detailed in the operating department chapter.

It should be remembered that the Santa Fe penetrated lengthy areas in various southwestern states, which, prior to the Santa Fe's arrival, were undeveloped and uncultivated. Ranches, mines and various industrial pursuits, slowly but surely changed those vast areas into civilized, prosperous communities. The Santa Fe



Diesel engine and train shown entering tunnel at Cajon Pass.

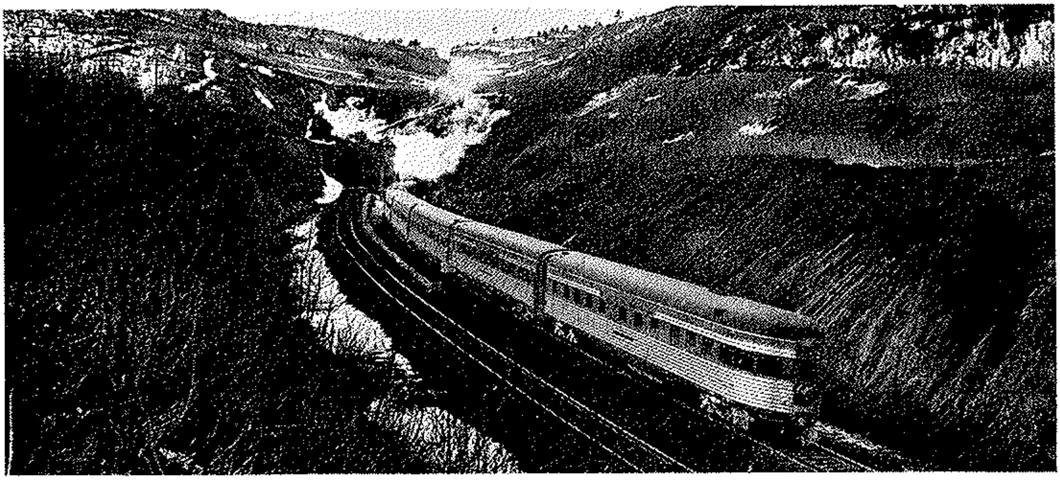


East portal of westbound tunnel on Raton Mountain.

early founded a land department, the functions of which were to locate ranchers, miners and industrialists on lands favorable to their individual pursuits. Transportation of food and supplies and the assurance of adequate fuel and water were self-imposed obligations which the Santa Fe to this day respects and fulfills. It was that kind of teamwork which enabled southwestern pioneers to prosper and the Santa Fe to become one of the nation's vital transportation agencies. Development of Santa Fe territory will continue for many decades.

Thousands of trains, containing millions of passengers and tens of millions of tons of freight, annually move over Santa Fe rails. Santa Fe people feel that there is no smoother, finer, safer track and roadbed in the country.

In later years, heavier rail, longer ties, sturdier and heavier joints, the use of heat treated bolts, heat treating and surface grinding of new rail ends, use of larger and heavier tie plates and anchor spikes, hydraulic pressure grouting and other efforts directed toward increased roadbed stabiliza-



The Chief shown entering Raton tunnel. The eastbound tunnel here is 2,040.6 feet, and the westbound is 2,789.3 feet.

tion, have resulted in trackage facilities which permit the movement of volume traffic at high speeds.

All Santa Fe high-speed transcontinental lines have been designated as 131-132-pound rail territory. That means that much of that mileage and all new rail laid in that territory is 131-132-pound rail except in yards and other localities where lighter rail is preferable. The new standard 115-pound section will shortly replace the present 112-pound. Other rail weights in use by the Santa Fe are 60, 75, 90, 110 and 112-pound. The three last-mentioned sections were standard on Santa Fe main lines for many years and considerable present-day Santa Fe rail mileage consists of those weights of rail. All Santa Fe rails are steel and have been for many years. Beginning with 1936 all rails have been control cooled by the manufacturers to eliminate as far as possible interior defects in the head of the rail.

The earliest railways in the United States used wooden rails capped with thin iron strips, called strap rails. The first iron rails were imported from England in 1831 and by 1850 most American railways were being built of iron rails. The original steel rails were made in England by Henry Bessemer and perfected by A. L. Holley, an American. The first steel rail in the United States was rolled at the North Chicago Rolling Mills in May, 1865. By 1880, thirty per cent of all tracks in the United States were laid with steel rails. By the late 1890s, steel had almost completely replaced iron on American railways. The open hearth process, developed by William and Frederick Siemens of Germany and improved by Samuel T. Wellman, an American, has largely replaced the Bessemer process. Standard length of a rail is 39 feet. Previous standards were 33 and 30 feet. A 39-foot, 132-pound rail weighs 1,717 pounds, and it requires 232.5 net tons of rail for one mile of track.

Most rails are laid on embankments which is a solid bank of earth, rock or other material built above the natural ground surface to form the roadbed. Ballast, single or double track sections, may consist of gravel, crushed rock, slag, chats, oyster shell or volcanic cinders. Ballasted roadbeds contribute much toward a smooth riding, stable track, facilitate drainage, provide an even bearing for the ties, hold the ties firmly in place and discourage or check grass and weed growth. With good ballast there is a minimum of dust and maintenance problems are reduced. Of all ballast types, crushed rock is considered superior.

All Santa Fe ties are scientifically treated prior to use. They are laid or inserted square across the grade, dapped side up. They have been accurately pre-bored for correct gauge and are spiked in the bored holes regardless of end line. Tie spacers, tongs or wooden mauls are used when inserting or spacing ties to prevent smashing or splintering the wood fibre which materially shortens the life of the tie.

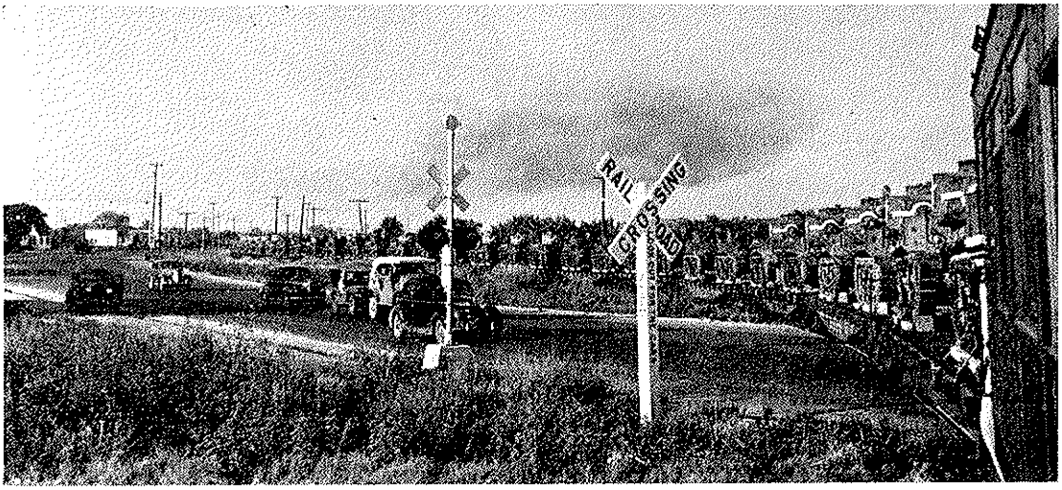
The standard tie for Santa Fe high-speed main line track is nine feet in length, seven inches thick and nine inches wide. There are large numbers of the previous standard, eight feet long, six to seven inches thick and eight to nine inches wide. Ties are spaced from 10¼ to 11½ inches, averaging 20 inches center to center. All adzing and other work which prepares ties for immediate use is done at one of the Santa Fe's four timber treating plants. When necessary to adze ties for plates, gauging or wheel marks, the entire adzed portion including the seat of plates is swabbed with a hot wood preservative.

Tie renewals require particular attention. In determining the necessity for replacing a tie under main or side track, its condition as to decay and wear, the condition of neighboring ties and the importance of the track are given special consideration before decision is made that tie should be removed.

In Santa Fe practice, preparatory to ballasting, base of rail levels are run and profile prepared by division engineer on which is plotted the proposed base of rail grade line. Care is taken in laying grade line in tunnels and under overhead structures, at station platforms and fuel and water stations, to avoid disturbing required clearances. The profile is submitted to the chief engineer for approval.

One line of grade stakes is then set for tangents and for low rail of curves ahead of skeletonizing and unloading of ballast. The stakes are set at intervals of 100 feet on tangents and fifty feet on circular curves, at point of spiral, point of spiral curve, and usually at one-half inch elevation points on spiral curves or runoffs and at breaks of grade. Center stakes are set immediately in advance of final surfacing with top of stakes at approximately ballast grade.

When necessary to resurface a curve "out of face" (repairs proceeding completely and continuously over a given section of road), the roadmaster calls on division engineer for grade stakes which are set in accordance



Traffic halts at a railroad crossing, safely protected with flashing lights, while a long freight train rushes to its destination.

with table provided in system standard plans. Where general surface of curve is good, with the exception of a few bad spots, proper surface may be restored by section foreman without the aid of stakes.

The standard rail gauge in the United States is 4 feet 8½ inches, and that gauge must be used on tangent track and on curves of six degrees and under. On curves over six degrees, gauge is widened ⅛ inch per each additional degree of curvature to a maximum of 4 feet 9⅛ inches. Gauge, including widening due to wear, must never exceed 4 feet 9¼ inches. Where gauge is widened on curves, widening must extend full length of curve and taper to standard gauge at points where rails are level.

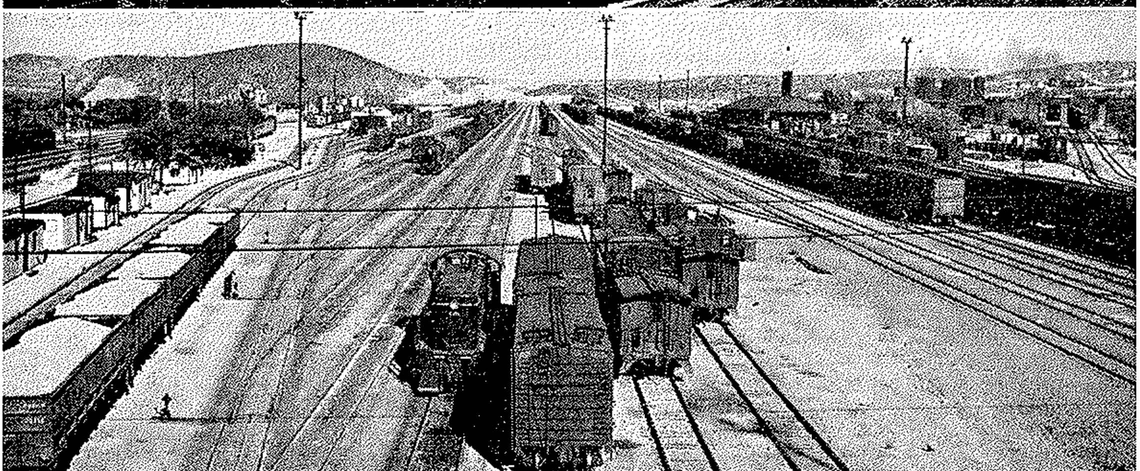
Curves are expressed in degrees, minutes and seconds. A curve is a part of a circle. The sharper the curve, the smaller the circle and the shorter the radius. To determine the degree of a railway curve, a line sixty-two feet long, with a knot at the middle, may be stretched on the gauge side of the outer rail at a well-lined portion of the curve. Each inch of distance from the center knot to the gauge side of the rail indicates one degree of curvature. If the distance is two inches, it is a two-degree curve.

Railway curves are of two general types: simple, which forms an arc of a circle of a single radius; compound, in which two or more contiguous simple curves of different radii but having a common direction at their junction points effect a continuous change in the direction or alignment of the track. A spiral or easement is placed on the ends of either type of curve to taper off end of curve and provide smooth riding. Reverse curves are not used on Santa Fe main line track or on any branch or spur if their use can be avoided. Turnout and vertical curves are other curve types. A triangular arrangement of tracks, called a "wye", is used for turning locomotives, cars and trains.

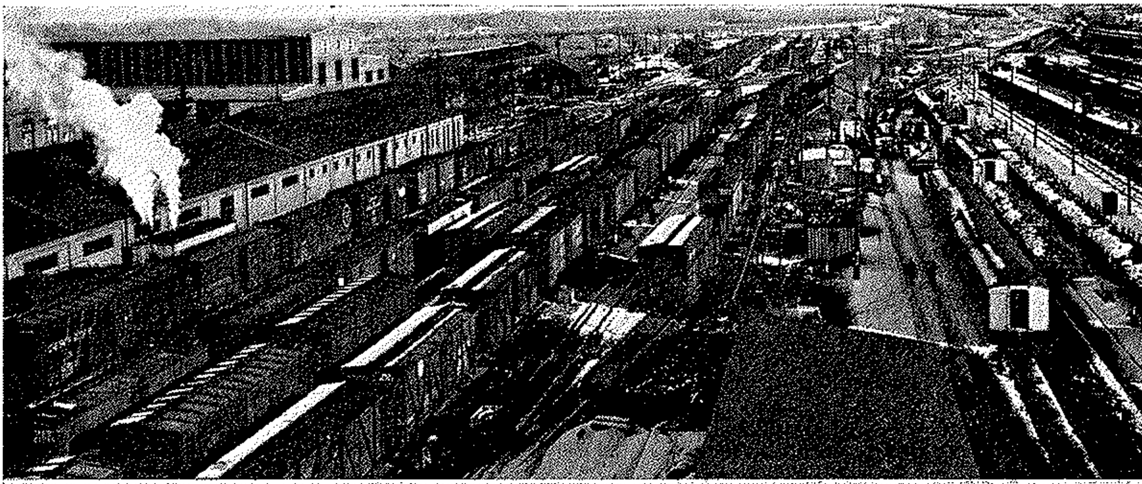
The outer rail on curves is elevated to balance or resist the overturning or centrifugal forces which are set up by a train rounding the curve. The degree of curvature and the authorized train speed govern the extent of the outer rail elevation. The specified elevation, alignment and gauge of high-speed curves on main line track are maintained as perfect as practicable, and curves are frequently checked for defective rails and joint bars.

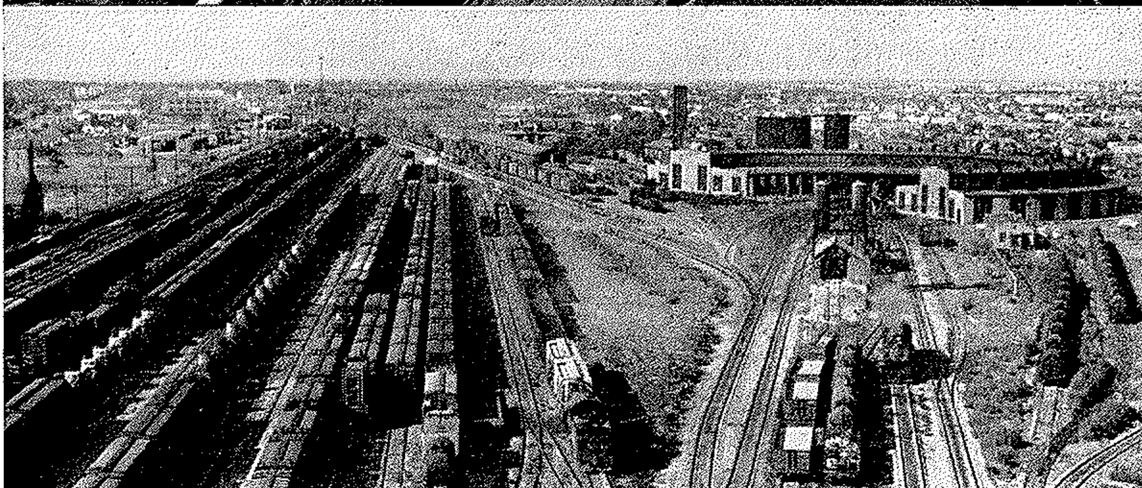
The resistance of curves is usually expressed in pounds per ton per degree of curvature, variously estimated from .50 pound to 1.72 pound, generally at .80 pound, which is equivalent to a grade of .04 per cent. Resistance of locomotives in passing curves is higher than for freight and passenger cars because of the long driving wheel base of the steam locomotive. Curve and grade resistance are dependent on many factors including wind and temperature. Locomotives are given a tonnage rating based on track curvature, grades and make-up of train.

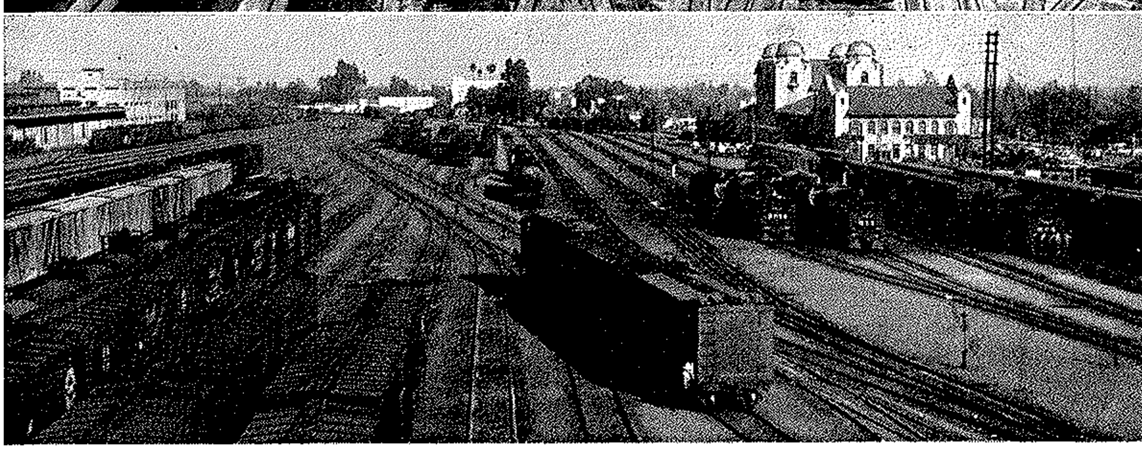
Santa Fe tracks are standard gauge, as are those of 99¼ per cent of all the rail-

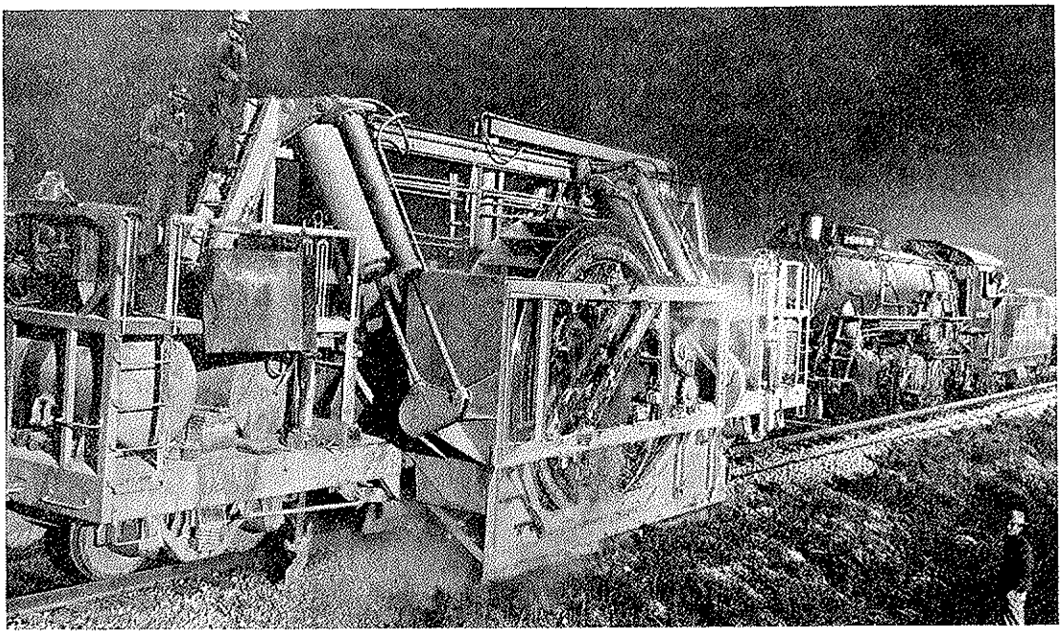


At terminal or division points as well as at populated communities, the Santa Fe operates sizable yards to facilitate freight traffic and train handling. This and the opposite page show counterclockwise: Coach yard and Diesel repair shop, Chicago; freight yard at Kansas City, Mo.; Barstow, Cal., yards; from atop Santa Fe Elevator "A" at Argentine we see the Santa Fe yards, largest on the system; San Bernardino, Cal., yards—passenger station at right; general view of yards and facilities at Amarillo, Tex.; repair tracks at La Junta, Colo., with storehouse at immediate left.









Ballast cleaner, an unusual step forward in the mechanization and economy of track maintenance, developed exclusively by Santa Fe engineers. Foul ballast in the shoulders, which prevents proper drainage and which, in turn, causes soft and uneven track, is elevated and passed through screens which remove dirt and foreign matter. The clean ballast is then deposited to its original position and the dirt and foreign matter wasted outside of the ballast section. This machine performs the work more expeditiously and economically than any other method previously used.

ways in the United States. That permits free interchange of freight and passenger cars. Ancient Roman chariots were built with a clearance of about 4 feet 8½ inches between wheels. England carried through a similar gauge, first to coaches and carts, then to tramways. Many of America's first locomotives came from England so the gauge became popular here although by 1871 there were nineteen different gauges in the United States. The present gauge was adopted as standard in 1878.

Rail laying or relaying on the Santa Fe is done by track crews known as steel gangs. Rails are laid with staggered joints, each joint being as nearly opposite the center of the other rail as practicable. Rails less than 24 feet in length are not used in Santa Fe main track except where necessary at railroad crossings or turnouts and then only as permitted by standard plans. Rails on curves of ten degrees and less are not precurved. Precurving of rails for curves sharper than ten degrees is optional with roadmaster.

The rails are laid to line and gauge one at a time and not in strings. Care is taken to obtain correct gauge and good line, the gauge line being ⅝ of an inch below the top of the rail. Before spiking joint ties, rail joints are applied and bolts drawn tight to provide correct alignment of rail ends. Track gauge is used close to but not at rail joints, also at intervals of approximately four feet. In signal territory, all joints are bonded as the rails form a part of the track circuits (electrical) which operate the automatic block signals.

An average of 271 thirty-nine-foot rails, from 3,250 to 3,520 ties, 6,500 to 7,040 tie plates, 542 joint bars, 1,626 bolts, and from 26,000 to 28,160 spikes, are required for each mile of heavy duty main track.

Proper allowance for expansion is secured by the use of metal shims at joints, the correct allowance being determined by the temperature of the rail secured by a rail thermometer. That allowance ranges from one-fourth of an inch at zero to one-sixteenth of an inch at 100° F., with 39-foot rails. Rails are not laid when the temperature is below zero.

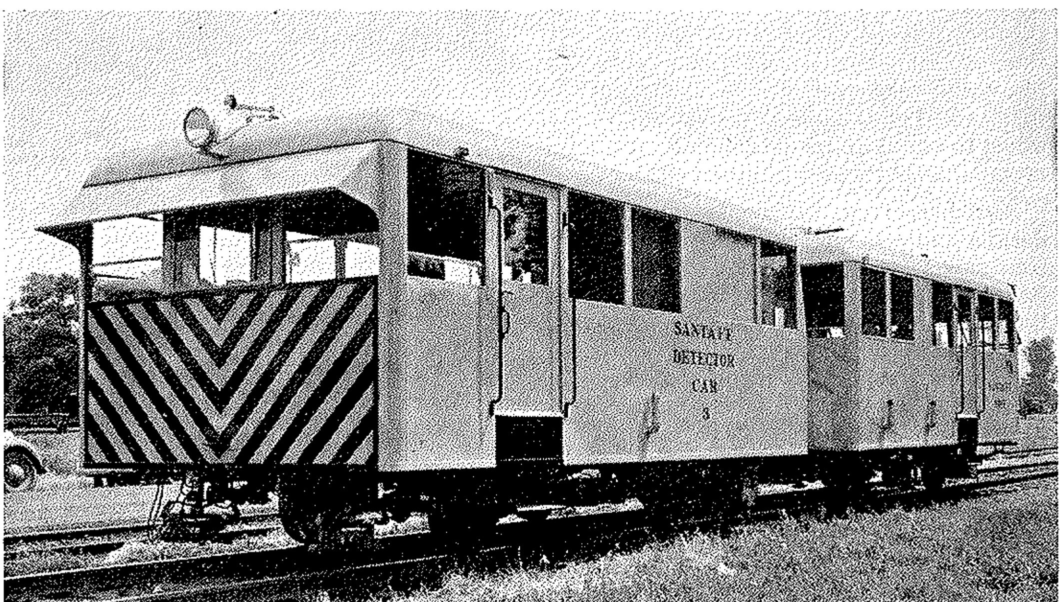
With four-hole tie plates, all ties are spiked with not less than two to each rail (four per tie) on tangents and curves up to and including six degrees. On curves over six degrees, a third spike is driven on the gauge side of each rail or on the outside in some instances. Spikes are started and driven vertically, square and snug against the rail. With eight-hole plates, in addition to these four spikes per tie, two anchor spikes facing toward the rail are used, one on each side of the rail, and staggered in relation to the other spikes. Such plates are used on heavy duty main line, curves, switches, turnouts and at other decisive points.

Rail running or creeping is controlled by the use of rail anchors. Rail anchors are applied according to standard plan but always in sufficient number to hold the rail. Yielding foundations, lack of drainage, improperly spaced ties, loose spikes and bolts and other factors promote rail creeping. The application of brakes and the roll of traffic result in the movement of the rail. If the rails run together the end post of insulated joints is crushed; if they pull apart the bushings are crushed. Anchors usually are applied in pairs, one on each rail on the same side of tie. Adequate anchorage must be provided at turnouts, railroad crossings and insulated joints.

All Santa Fe main lines and many branch lines are ballasted. Ballast is laid at a depth of six to twelve inches beneath the ties depending on the traffic and character of the soil and drainage conditions. All ballast pulverizes under heavy service and must be replaced. High water also affects it adversely. Old ballast still serviceable is cleaned with ballast forks or mechanical devices which remove dust, dirt and weed growths. In ordinary repair work, ballast is tamped into position with tamping picks and shovels.

Ballast for new track work is delivered in special side and bottom dump cars which spread the ballast between rails and on the shoulder. Power jacks lift the track and the ballast is tamped under the ties. The operation is repeated once or twice until sufficient ballast has been applied. The ballast is then mechanically tamped and the track is given a final surfacing and dressing. Where eight-foot ties are used, the ballast must be thoroughly tamped from end to fifteen inches inside of the rail base; with nine-foot ties, nineteen inches inside of the rail base.

Top of ballast is maintained three inches below top of ties under frogs, guard rails and switch points including connecting and head rods to help in the removal of accumulated sand, dirt, snow or ice.



The Santa Fe owns and operates two rail flaw detector units, each consisting of detector and tow car, continually over all important main tracks. Interior defects of all kinds which are not visible from the outside of the rail are detected and such defective rails immediately removed from track.

Water is the worst enemy of track and every effort is made to keep tracks and roadbeds properly drained. Where the drainage is toward the roadbed, suitable ditches are provided where practicable to intercept and divert the water. Frequent inspections are made of ditches and waterways leading to and from bridges and culverts which must be kept open for free and unobstructed passage of water. When erosion endangering roadbed is discovered, immediate action is taken by division officers who are promptly notified.

After snowstorms, ditches are cut through the snow to provide drainage and prevent flooding of track in case of sudden thaw. Measurements at bridges or culverts of extreme high water or extraordinary freshets are taken from the base of rail to the surface of the water or high water mark. The division engineer keeps a record of such water marks. That and other weather records are carefully reviewed when new bridges or openings are contemplated. Where drainage conditions are exceptionally bad, consideration is given to blind or open drains parallel to track and outside of the ends of ties, or to the installation of especially designed drainage systems.

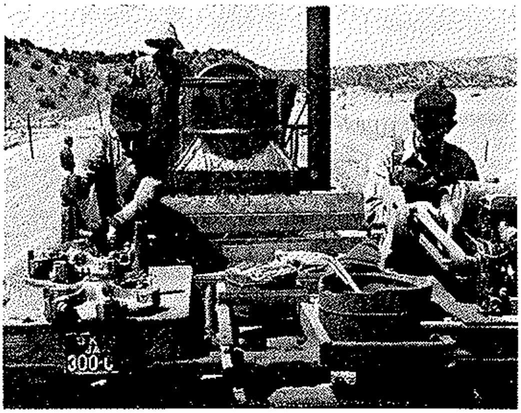
Track on curves will drain off the larger portion of water if the ballast shoulder on the low side of the curve is clean even if the high shoulder is foul. It is therefore important that a clean ballast shoulder be maintained on the low side of curves. Care is taken to maintain inside shoulder at a minimum standard width to assist drainage.

Switches, frogs, turnouts, guard rails, derails and other track facilities are given continuous inspection and maintenance. Switches and frogs must be kept in good line and surface and all bolts tight. Switch points must fit tightly against stock rail and throw freely. Guardrail flangeways are maintained at specified widths. At regular intervals all No. 1 head rods, also all connecting and head rod bolts in main track switches are removed and cleaned with gasoline and painted with whitewash. When dry they are inspected and renewed if cracks or defects are noted. When tracks connected with a main line are out of service for an indefinite period, the main track frogs, switch points and lead rails in center of track are removed.

Maintenance work in the Santa Fe's large terminal or consolidation yards is varied.

Workmen tighten nuts holding angle bars and rail with power wrench. This is one of the final operations in laying the new rail.

Angle bars are spread so rail may slip into place. Grippers used by workers prevent mashed fingers and other injuries.



Grinder on right sharpens the tie adzer bits which are being placed in adzer head by fellow-worker on left.

RAIL LAYING OPERATIONS

Power adzers cut new seats in the old ties for the tie plates on which the new rail is to be placed.

Track workers push bolts through rail joint bars and "start' nuts which will be tightened later with power wrenches.

Old spike holes are sealed with creosoted plugs to keep water from seeping in and rotting ties. Note workmen with bundles of plugs.

Workman draws hot creosote from heater. The use of this preservative lengthens the life of a tie to 25 or 30 years.

Tie plates are placed in position on the ties. Note with what snugness they fit into the adzed tie seats.

Automatic spike pullers, powered by a gasoline engine, easily keeps ahead of the steel gang as they remove old track spikes.

All tracks are dressed with cinders or screenings level with top of ties in the center but left a little low at the end of ties and still lower between tracks where subgrade is sandy, porous material which will allow proper drainage. Rock, sand, and dirt are kept away from rail and fastenings including tie plates and spikes.

Runways where switchmen work are kept smooth and free of obstructions at all times. Operations within a large yard are heavy and continuous with resultant wear and tear on all existing facilities. Chipped or blunt switch points, worn stock rails and frogs, broken joint bars, defective rails, irregular alignment on curves and many other possible defects must be noted.

All signs, signposts and markers placed within or adjacent to Santa Fe right of ways must conform with standard specifications and design as approved by the chief engineer system and the vice-president in charge of operation. There are, in addition, various governmental, state, county and municipal laws which must be respected in relation to the placing of signs and markers and the wording or legend painted or mounted thereon. Specifications begin with the type of material to be used within particular territories and for particular purposes, the style of lettering, color, location, mounting and maintenance. Cement, metal, wood, glass and other materials are utilized.

The highway crossing and no trespass signs are perhaps the most familiar of all right of way signs. Less familiar but of great importance are railroad crossing, speed control, whistle, mile post, culvert, trestle and bridge, junction, derail, mail, tank, clearance, gate, blind siding, end of circuit, preliminary section, various danger, place no obstruction, city limits, state and county boundary lines, section limits, maintenance limits, land monuments, alignment markers defining the correct position of tangents, easement spirals and curves, snowplow markers indicating obstruction to snow equipment, various warning and safety, special track material, switch target, spring switch, station and yard limit, watchman off duty, gates not working, and incidental hazard approach signs for the benefit of patrons and employes.

All Santa Fe depots carry the name of the station. Within and without the depot and grounds are numerous signs. All must be approved. The Santa Fe emblem appears at numerous locations throughout Santa Fe premises, as well as the familiar words "Grand Canyon Line". Santa Fe buildings and departments usually are identified by signs or appropriate lettering.

Telltales are an important safety installation on the right of way. They consist of a series of dangling ropes suspended over the track from a crossarm at a height suitable for striking the heads of trainmen standing on the roof of moving cars, warning the trainmen to stoop immediately. Santa Fe standards require that telltales be installed not less than 50 feet or not more than 400 feet on each side of structures over tracks where the vertical clearance is less than 22 feet above top of rail. Telltales are familiarly seen at underpasses, bridges and tunnel entrances.

On Santa Fe main lines, emergency rails are placed on standard rail racks at intervals of one every four miles on single track and every two miles on double-track territory. On important branch lines, the same relative number of emergency rails are maintained at section headquarters. On unimportant branch lines, emergency rails also are carried at section headquarters, one rail for each six miles of track, when 75-pound and heavier rail, and one rail for each four miles of track, when less than 75-pound rail. On branch lines, one emergency rail may be carried at siding between section headquarters. Where necessary, emergency rails are given a coat of crude or black oil which is renewed at intervals to prevent rusting.

Track and switch ties removed from track are piled adjacent to the track, carefully inspected by roadmaster and culled before being destroyed or otherwise disposed of. Ties fit for further use are piled at right angles to the track; those unfit for use except as fuel, parallel to the track. In the interest of accurate and uniform reporting and accounting, time books and tie reports show all symbols and classes of ties and state whether hewn or sawn for all ties inserted in track or on hand.

Switch points with clamps are used to close track for passage of trains during the hours rail laying is in progress. Closures at end of day's work are made with standard joints full bolted and are made on tangents where practicable. Proper slow signals and orders are placed. Division engineer, trainmaster, and roadmaster are advised by wire daily as to the progress of the work and the limits over which speed of trains is to be restricted.

The Signal Department

THE Santa Fe's signal department designs, installs and maintains Santa Fe automatic block signals, manual block and train order signals, interlockings, remote control, automatic train control, centralized traffic control, highway crossing signals and the signaling features of spring switches.

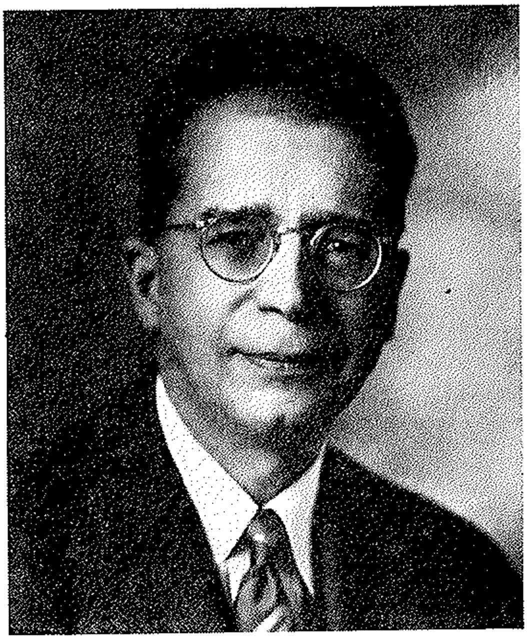
Signal engineer system, reporting to the chief engineer system and to the operating vice-president, has a system-wide staff of signal experts who insure the proper installation and operation of Santa Fe signal systems. Those procedures conform in all details with Section 26 of the Interstate Commerce Act as amended August 26, 1937, which states:

> "The railroad company is responsible for the installation, inspection, maintenance and repair of block signal systems, interlocking, automatic train stop, train control and cab signal devices, and other similar appliances, methods and systems used or permitted to be used on its line. It must know that all installations, inspection tests, and repairs are made and reports are made and filed as required, and that all parts and appurtenances of the devices used are maintained in condition to meet the requirements of the law and these rules, standards and instructions."

Speed and safety, the most commendable aspects of modern railway operation, would not be possible without present-day scientific signaling devices which safeguard and control the movements of trains and, through the operation of switches, establish routes of movement.

Santa Fe signals not only embrace all requirements of state and municipal regulatory bodies and those of the Interstate Commerce Commission, but meet Santa Fe established standards which are the outgrowth of continuous studies and investigations on the part of Santa Fe signal engineers. That is in keeping with I. C. C. order, dated April 13, 1939, which reads in part:

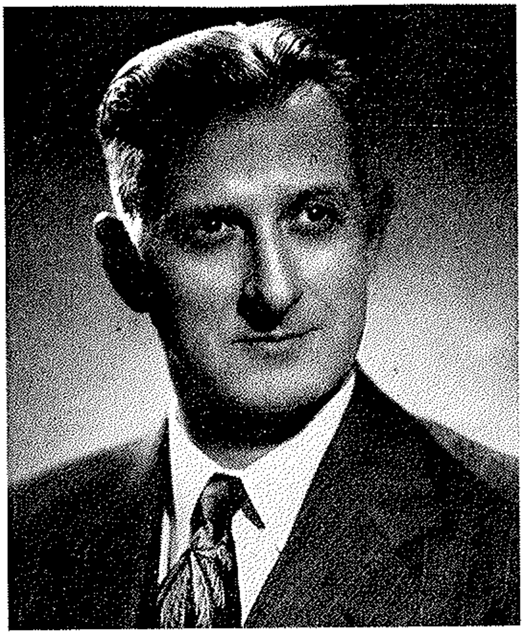
> "Nothing herein contained shall be construed as prohibiting any carrier from enforcing additional rules, standards and instructions not inconsistent with the said rules, standards and instructions, tending to a greater degree of precaution against accidents."



G. K. Thomas, signal engineer system, with headquarters in Topeka, Kan.

The Santa Fe's entire transcontinental main line, Chicago to San Francisco, Los Angeles and San Diego (via Raton and via Amarillo) is equipped with automatic block signaling. Similar protection is provided on the line between Newton and Galveston, and on much of the lines between LaJunta and Denver and between Lubbock and Temple. That mileage embraces 1,876 miles of double-track and 3,084 miles of single-track railroad—a total of 6,836 miles of track equipped with automatic block signaling on the Santa Fe system lines.

Automatic block signals consist of a steel structure or post mounted beside or over the track and carrying thereon a semaphore arm and a colored light, or in the latest type of signal, a powerful colored light without a semaphore arm.



V. O. Smeltzer, assistant signal engineer system, with headquarters in Topeka, Kan.

The word "block" indicates a section of track of defined length the entry into which by trains is regulated or authorized by a fixed signal at the entering end of the block. Block lengths vary depending on the volume of traffic, the nature or character of the line (tangents, grades, curves, bridges) and the braking distances. The signals generally are spaced about two miles apart. In some localities they are closer because the areas are congested or speed of trains is slower.

Automatic block signals are controlled by electric circuits and arranged to display three distinct indications:

Stop—Indicated by a horizontal arm or by a red light.

Restricted Speed—Indicated by an arm at forty-five degrees upward or by a yellow light.

Proceed—Indicated by a vertical arm or by a green light. This means that the train may proceed without restriction insofar as the signal system is concerned.

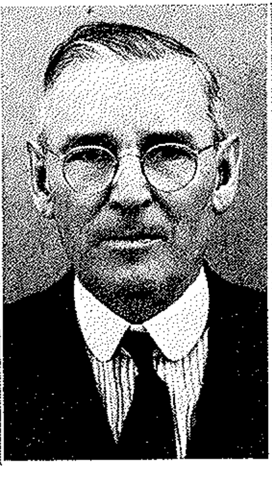
As the train speeds along the track it automatically and continuously sets up its own protection by affecting an electric current in the rails which causes the signal immediately in the rear of the train (entrance to first block) to indicate *stop* for protection against following trains, while the second signal in the rear (second block) indicates *restricted speed*. The remaining signals indicate *proceed*.

On single track the automatic signals are controlled so that the signals in advance of a train governing movements in the opposite direction are affected in the same manner as those in the rear, that is, the train also sets opposing signals in *stop* or *restricted speed* position as the case may be. A train on single track thus is fully protected in both directions as it speeds along the rails. An open switch or a broken rail automatically sets the signals at *stop* in the

SIGNAL ENGINEERS

D. W. Fuller
Eastern Lines

H. A. Appleby
Western Lines



E. Winans
Coast Lines

W. L. Talevich
Gulf Lines

same manner as the presence of a train in the block.

Signals also are equipped, where required, with means for displaying a fourth or *medium speed* indication consisting of two yellow lights on the same post to provide a warning at still further distance (entrance to third block) in the rear of the train. This extra warning is used particularly where the speed of trains is very fast. In new installations additional aspects are being provided for turnout movements.

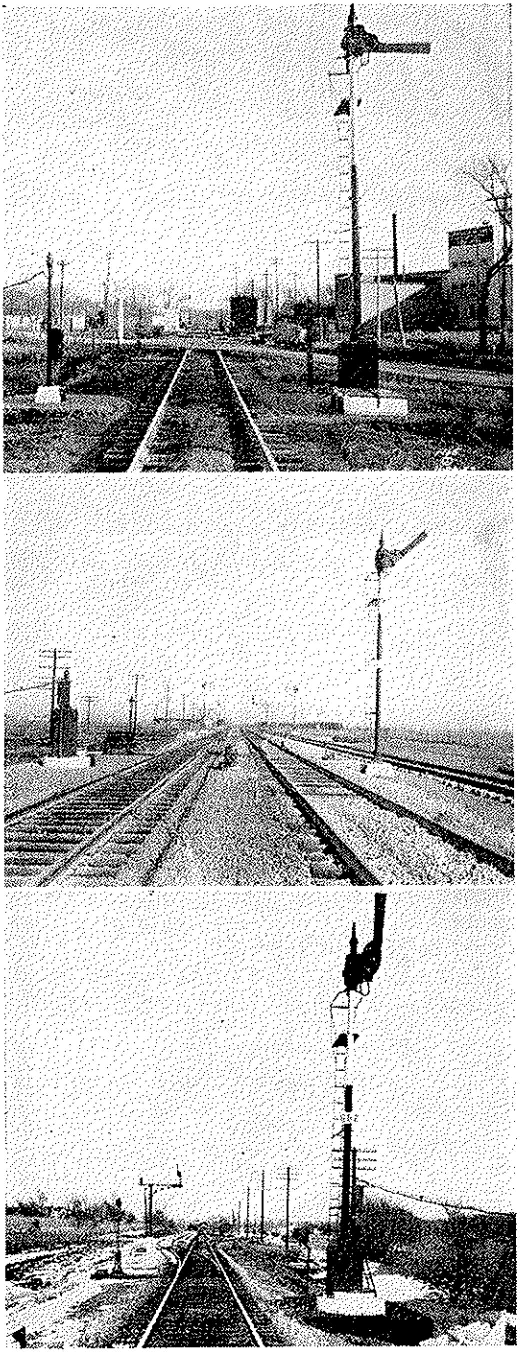
Electric circuits and other apparatus used in connection with signaling are designed upon the basic principle of inherent safety which provides that a broken electric wire, an exhausted battery or any other similar defect will automatically release the controlling mechanisms in such manner that the force of gravity will come into action and cause the signal to display the red or stop indication. In other words, it requires electrical energy to raise the signal to green or yellow. Lacking that energy, the signal drops to red by gravity.

Santa Fe rules further require that in case a signal is imperfectly displayed in any manner it will be treated as a *stop* signal and reported at the next agency station. The signal maintainer is immediately called to repair the defect.

Some portions of Santa Fe lines are protected by manual block. The signals are located one at each entrance to a block and are mechanical. They are operated under block signal rules by the manual block operators located at the entrance to the blocks.

With the exception of centralized traffic control and other signal indication territory, the train order system is in effect on the Santa Fe. Train order signals are placed at suitably spaced intervals (usually at stations) and are handled by operators who cause a proceed indication to be displayed if there are no orders and a stop indication if orders are to be delivered.

The Santa Fe has a total of 220 interlocking plants located at terminals and important operating points which consist of an assembly of machinery and equipment connected with signals and with switch mechanisms so that an operator located in a central control station can throw the switches and clear the signals throughout a large area. All levers are "interlocked" by means of a mechanical locking bed or a network of electric circuits is used, providing a safety system in which plant functions are automatically checked against each other. That prevents hazardous conditions being set up

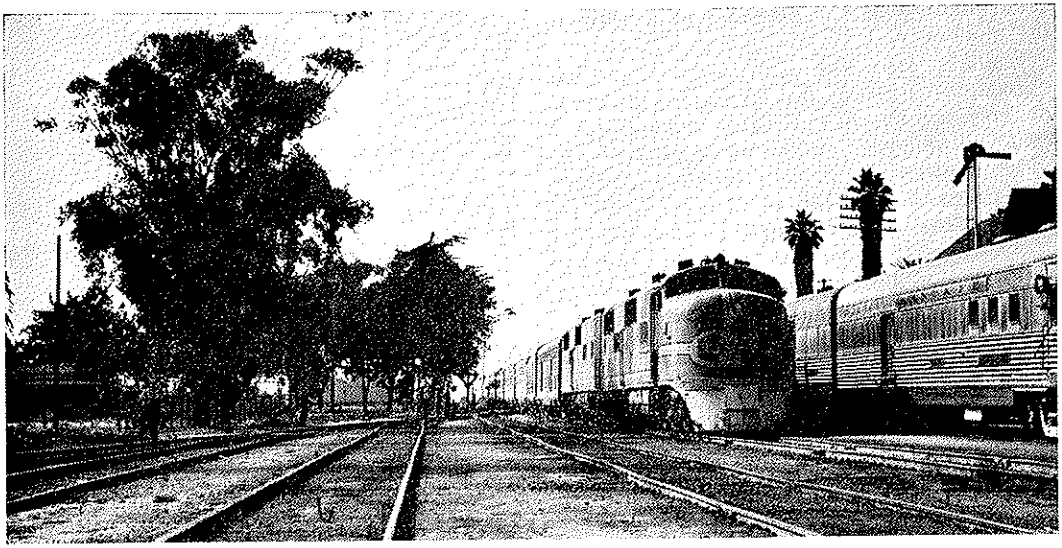


Automatic block signals:

Top—Stop; indicated by a horizontal arm or by a red light.

Center—Restricted speed; indicated by an arm at 45 degrees upward or by a yellow light.

Bottom—Proceed; indicated by a vertical arm or by a green light.



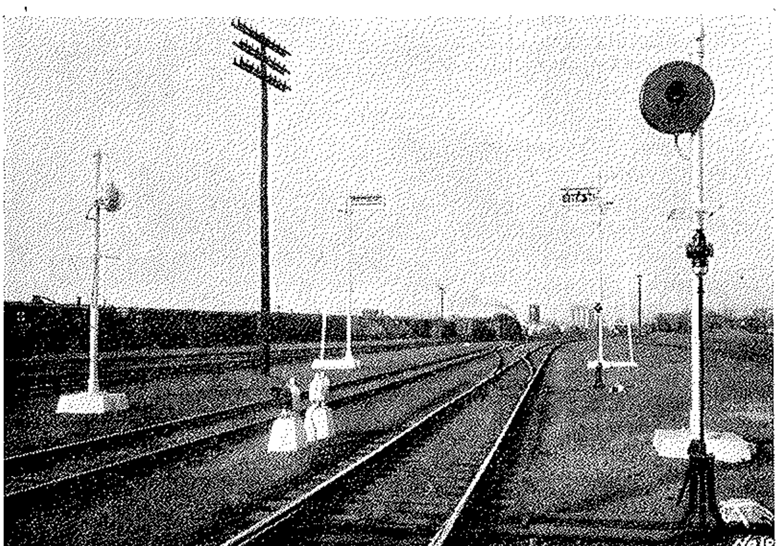
Manual block or train order signal (at extreme right), Oceanside, Cal.

either by mistake on the part of the operator or by any other occurrence.

The Santa Fe has 36 automatic interlocking plants at railway crossings whereby trains approaching the crossing on two or more intersecting lines are automatically protected against each other. Electric circuits are used to automatically check the signals on one railway against the other so as to prevent the possibility of conflicting routes being set up. The signals, electrically controlled, clear only one train at a time, "first come, first served."

Santa Fe centralized traffic control installations (some 640 miles in operation in July, 1947) are continually broadening. Present C. T. C. installations include the lines between Fullerton-San Diego, Clovis-Belen, Waynoka - Pampa, Dodge City - Kinsley, Algoa-Houston, Holliday-Olathe, and Riverside-Fullerton. Centralized traffic control permits the operation of signals and switches from a central office controlling train movements over an operating district or other extensive territory.

The Santa Fe has 175 miles of continuous type automatic train control (Pequot to Fort Madison) which automatically reduces the speed of or stops trains if occasion requires. Brakes also are automatically ap-



Colorlight high and dwarf signals at east end of Dodge City passenger yards; also switch circuit controller, and two train signs which indicate to yard crews when a westward train is approaching on one track or the other.

plied when the speed of the train exceeds a prescribed rate, application continuing until released by the engineman after the speed has been reduced to the predetermined and prescribed rate.

There are 1,600 Santa Fe highway crossings protected by automatic warning signals which are built in accordance with national standards. These safety signals warn motorists and others of approaching trains. One style of highway crossing signal gives its warning by a large swinging disc carrying a red light and an electric gong. The newer style of crossing signal, in use at most Santa Fe crossings, gives its warning by two large and powerful red lights, flashing alternately, and by an electric gong. Gates protect some Santa Fe highway crossings.

There are 740 spring switches on the Santa Fe's lines with associated automatic signals. Spring switches speed up the movements of trains by making it unnecessary to stop trains to enable the train crew to open and close switches when trains are leaving side tracks and entering main lines. That is done automatically and under complete signal protection. The connecting rod is equipped with a powerful spring which permits switch points to move when trailing movements are made through the switch but which otherwise holds points firmly in position. It is also equipped with an oil-filled buffer to reduce the shock of the points returning to position after a train has trailed through.

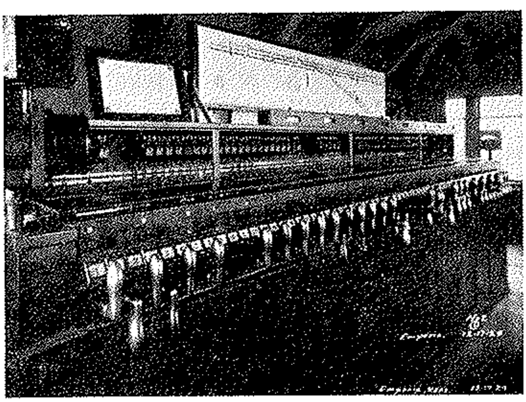
All the above equipment is installed and maintained by the signal department in cooperation with Santa Fe track, maintenance and such other departments as may be involved. The development and design of electric circuits for the various signal installations is extensive and complicated. All signal apparatus is checked and double-checked by trained signal engineers to insure that equipment safely performs its functions of safeguarding and facilitating train movements and will continue to do so.

Safety is the basic ingredient in all signal installations, operations and practices. With safety established, attention is directed toward the elimination of delays and providing for higher speeds which will permit expeditious movement of passenger and freight trains—the ultimate objective of all Santa Fe operations. To accomplish that, the signal department's system-wide organization constantly applies its skill and resources.

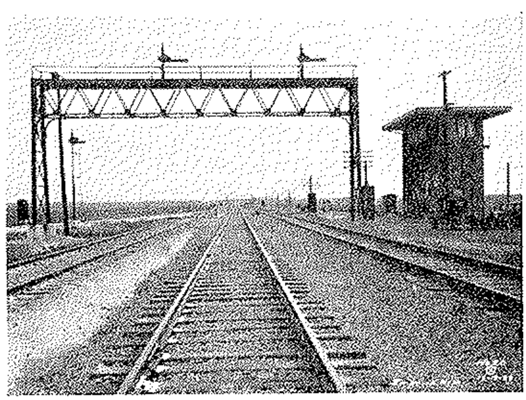
On his Topeka staff, the signal engineer system is assisted by an assistant signal engineer system, an office engineer, three assistant engineers, draftsmen and clerical force. Signal repair shops are maintained at Topeka and San Bernardino.

The signal engineer system and staff prepare standard plans and standard instructions for signal work both in construction and maintenance, determining the kind of apparatus and materials to purchase and standardize and arranging for such purchase with the Santa Fe's general purchasing agent and store department. The central organization at Topeka also develops typical circuits for the various kinds of signal installations which are used on the Santa Fe system and performs considerable development work in connection with signals and their installations.

Signal developments are continuous. In the case of a major development, the signal engineer system's staff takes over the entire engineering of the project. Generally, how-



Electric interlocking machine, Merrick, Kan.



Interlocking plant at Merrick, Kan.

C. T. C. instrument house at west end of siding at Bazar, Kan., inside view, Ellinor to Eldorado C. T. C.

ever, it is possible to turn over the designs of local installations to the grand division signal forces—after typical circuits, kinds of apparatus and methods have been developed.

The signal engineer system's central organization also handles matters pertaining to inspections as required by the various divisions of the Signal Inspection Act which went into effect in 1937. Weekly signal performance reports are received from each grand division. These are classified and reported monthly to the Interstate Commerce Commission. All changes in any parts of the signal system are the subject of special application, individual plans in connection therewith being presented individually for the approval of the I.C.C. Statistical reports annually are made to the I.C.C. covering all signaling features on the Santa Fe system lines.

Each grand division has a signal engineer who reports jointly to the general manager of the grand division and to the signal engineer system. The grand division signal organization includes an assistant signal engineer, engineers, draftsmen and assistants who prepare forms and estimates for various signal improvements and installations, lists of materials required, and local plans for signal installations, using as a guide the lists of materials, standards, and typical plans furnished by the signal engineer system.

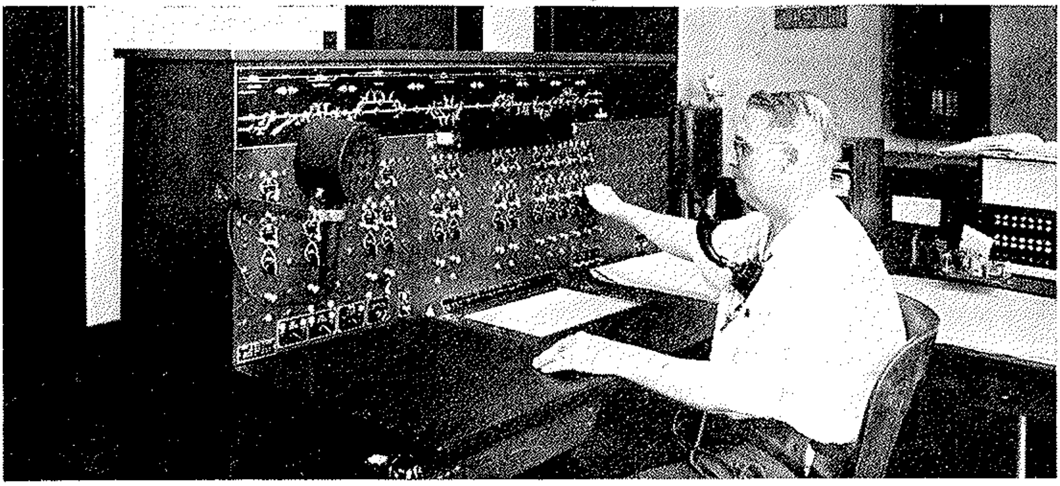
Each operating division has a signal supervisor who reports jointly to the superintendent and to the grand division signal engineer. The signal supervisor has direct charge of signal equipment on his operating division. His staff includes assistant signal supervisors, signal inspectors, signal maintainers, and repair and construction forces.

Signal maintainers are assigned to individual territories of varying lengths depending on the amount of signal equipment contained therein. Each maintainer has charge of all signal equipment on his territory. Construction and repair forces consist of signal crews, signalmen and assistants, who live in outfit cars and are moved to whatever point is most convenient for performing their assigned work. The latter consists of heavy and light installations and general signal repairs.

A regular program of signal maintenance is in effect which includes periodical inspections of all signal apparatus and equipment. The results of those inspections and tests are reported on forms which are filed at stated periods with the signal supervisor who in turn reports them to the signal engineer. All signal equipment and practices are of a highly specialized nature and forms, instructions, and standards are continually being developed and revised as found necessary or advisable by actual experience with the various kinds of signal equipment.

The fundamental law in all signal practice is that signal facilities be so installed and maintained as to be safe and suitable for service. Maintenance and repair work must not interfere with the safe movement of trains. When repair, adjustment, change or replacement is made in any part of the signal system which may affect the operation of that system, tests immediately are made to determine that proper operation is assured.

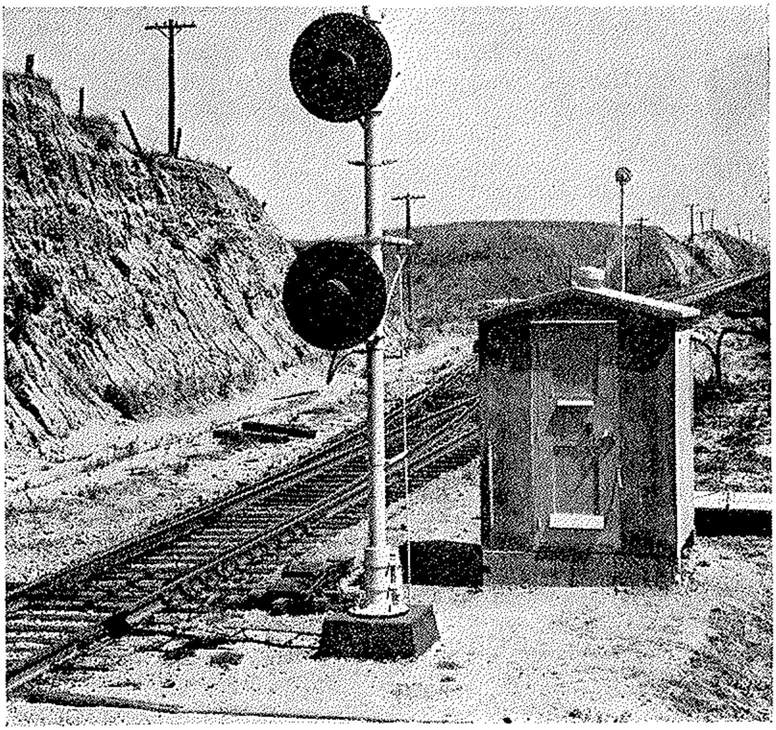
The operating capacity of long stretches of Santa Fe trackage facilities has been greatly increased by the installations of centralized traffic control, by means of which the movement of trains over routes and through blocks on a designated section of track is directed by signals controlled from a designated point without requiring the use of train orders and without superiority of trains. Such control is exercised at a central or control point where a machine, equipped with a miniature model of all tracks within the controlled territory indicates train movements by means of small lights. Enginemen are guided solely by signal indications.



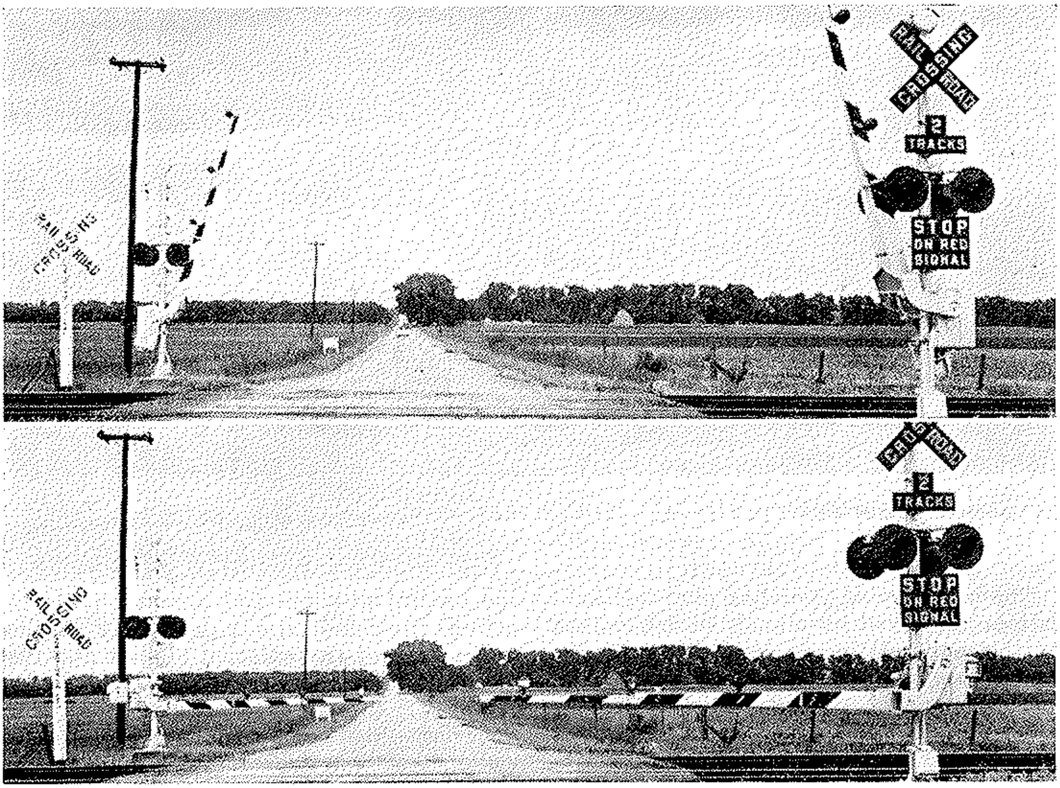
Another view of Ellinor to Eldorado C. T. C. Control machine and dispatcher at Newton, Kan.

The position of switches and the indications displayed by signals is determined by the manipulation of small levers in the C.T.C. machine. The system is so designed and constructed that it is impossible to cause signals to display indications authorizing conflicting train movements. The intermediate signals located between control points can clear for train movements only in the direction of traffic established from the control machine and are automatic in action, their indications depending on the indications of the adjacent signals and the location of trains.

The C.T.C. control panel has a top row of levers which control and operate electric switch machines which are located at the ends of each siding. These levers have two positions with "N" indicating "normal" for main line operations, and "R" indicating



Colorlight signal, C. T. C. instrument house and interlocking switch at end of siding, Las Flores, Cal. Green, clear signal; yellow over yellow, medium speed signal; yellow, restricted speed signal; red, stop signal.



Flashing light signals with automatic gates and bells at highway crossing near Hutchinson, Kan.
Top—No train approaching.
Bottom—Train approaching.

"reverse" for train movements into or out of a siding. A green light applied above the "N" or "normal" position of the switch lever indicates that the switch at the siding is lined up and safely locked in the correct position for a main line movement. A yellow light applied above the "R" or "reverse" position of the switch lever indicates that the siding switch is lined up for a train to enter the siding.

The control machine is equipped with an automatic traingraph which registers the entrance and departure of all trains at sidings as well as trains passing such sidings on the main line. Any mistake made in the operation of the levers will not cause an unsafe condition on the wayside signaling apparatus for the reason that all electrically operated switch machines are mechanically locked and it is impossible to display a proceed or clear signal until the switch governed by such signals is in the correct position and securely locked. The track circuits and other devices used in the C.T.C. system provide maximum protection under all conditions.

The centralized traffic control system provides an operating tool which allows quick action to be taken on planned train movements. There are no orders to be written and transmitted to train crews, no holding of trains for long periods at terminal points while waiting for other trains to arrive or depart. It is estimated that many C.T.C. installations produce an average saving of one hour for each sixty miles in running time of freight trains in addition to clearing lines for fastest possible operation of passenger trains.

Officers of the Santa Fe's signal department serve on many important committees within the Association of American Railroads. The signal engineer system is a past chairman of the signal section of A. A. R., and is now vice-chairman of the committee on signaling practice; the joint committee on highway grade crossing protection, and the joint committee on train operation, control and signals. These active committees cover developments, specifications, requisites and improved designs and standards for signal apparatus and systems.

Timber Treating Plants

THE Santa Fe annually uses some 2,250,000 cross, switch and bridge ties in the maintenance and construction of Santa Fe tracks. Each of those ties is scientifically treated to prolong its life and to enable it to better resist mechanical wear.

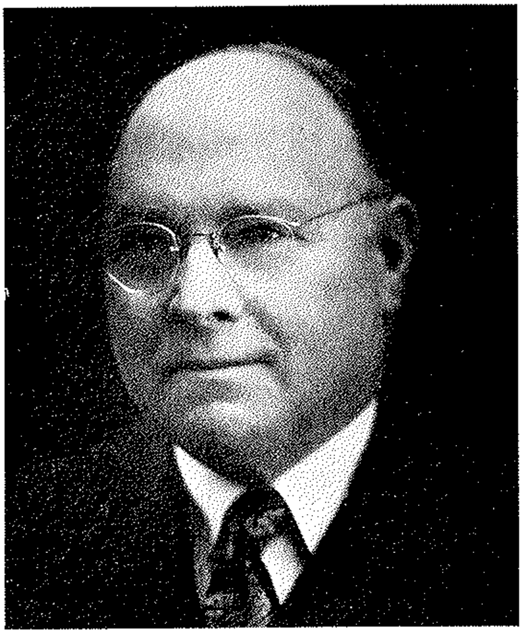
The Santa Fe annually uses many thousands of cubic feet of bridge piling, stringers and lumber; additional thousands of cubic feet of fence posts, stock pen posts, moldings, signal poles, tie plugs, pile heads, crossing planks, window sash, anchor logs, trunking and capping, and other timber items—all scientifically treated prior to use.

Those lumber products represent the Santa Fe's largest maintenance of way and structures expense item, exclusive of labor. At the end of 1946, cross ties in Santa Fe tracks totaled 58,383,000. In addition, there are large quantities of treated piling, timber and lumber in bridges and other roadway facilities.

Prolonging the life of those woods not only means an annual saving of many millions, but it insures a high degree of safety. Timber preservation thus has an inestimable value. The Santa Fe has been a pioneer in treating timber with chemicals.

The manager of the Santa Fe's timber treating plants, reporting to the chief engineer system, is charged with the supervision of all Santa Fe timber treating personnel, facilities and methods. Santa Fe timber treating plants are located at Somerville, Tex.; National City, Cal.; Albuquerque, N. M., and Wellington, Kan. From various states, timbers, ties, lumber and miscellaneous woods—southern pine, Douglas fir, western pine, oak, gum, cedar, spruce, hemlock and others—are brought to those plants for treatment.

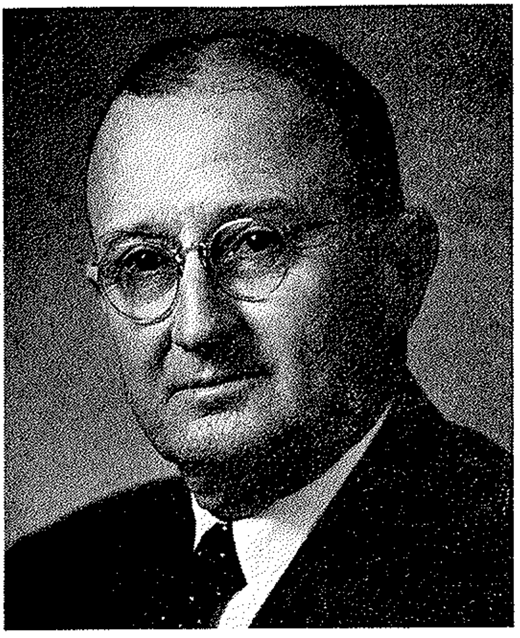
Santa Fe ties are inspected after being cut green by private operators under contract and, with other timber items, are cured or air-seasoned at the treating plants prior to being taken into the long cylindrical retorts where they absorb creosote mixtures under pressure. Line poles, piling, stringers and various timbers also are carried into the retorts where they absorb predetermined quantities of creosote-petroleum mixture—depending on type of wood, use, and other factors. Treated material is shipped throughout the Santa Fe system lines. The Santa Fe has some 400 special cars for transporting ties.



R. S. Belcher, manager of treating plants system, with headquarters in Topeka, Kan.

The manager of treating plants system and his Topeka staff, consisting of assistant manager, inspectors, chemist and clerical assistants, handle analyses, gauging and inspection of creosote loading at manufacturers' plants, chemical analyses of new preservatives, and analyses of preservatives from wood that has given special service. Reports of ties inserted as renewals are checked; ties used in new work and general tie renewal statistics are compiled. Annual inspection and check of ties in all tie tests, inspection of special tests, including especially treated timber bridges, wooden platforms, planked roadway crossings and fence posts are made, records kept, and service life computed.

Old ties removed from tracks are inspected and cause of failure is determined.



D. L. Murray, assistant manager of treating plants system, with headquarters in Topeka, Kan.

Branch line ties, bridge timbers, piles and miscellaneous lumber are checked and inspected for salvage in instances where such lines are abandoned. Other investigations concern termite infestation and decay in Santa Fe buildings.

The Santa Fe has under observation fifty-seven test installations of cross ties, comprising a total of 424.3 miles of track, which, with completed tests, total 464.5 miles of track. Those tests began in 1902 with the establishment of a "test section" at Cleveland, Tex., to demonstrate the value of various kinds of preservative treatment for cross ties.

For more than four decades, the Santa Fe has carried out one of the most outstanding examples of scientific research ever undertaken by an individual railway. Cross tie investigation has involved the study and observation of 2,390,680 individual cross ties treated with forty-one different timber preservatives or combinations of preservatives and involving thirty-one different species of domestic woods, in addition to five varieties of foreign woods. Of those ties, 998,048 are still in Santa Fe service and under observation; the remainder have been removed from track because of decay or other types of failures.

The timber treating department has a personnel of some 500 Santa Fe men and women. Each of the four treating plants is in charge of a superintendent who is assisted by an accounting and office staff, various foremen, chemist, stationary firemen, pump room engineers, various mechanics and machine operators, and laborers. The location and capacity of Santa Fe timber treating plants follows:

Location	Plant Acreage
Somerville, Tex.	310
5 cylinders 74″ diam. x 132′ long.	
Albuquerque, N. M.	91.5
2 cylinders 74″ diam. x 132′ long.	
National City, Calif.	61
2 cylinders 96″ diam. x 124′ long.	
Wellington, Kans.	103
2 cylinders 96″ diam. x 58′ long.	

Each plant has a powerhouse, engine room, office, bungalows, track scales, mixing sump, oil, water and separation tanks and cylinder house. There are extensive acreages set aside for storing and curing the various woods prior to treatment; and other areas for storage following treatment. Adzing, boring, incising, preframing and other plant operations are performed in yards and in various woodworking buildings. A network of tracks facilitates yard and plant operations.

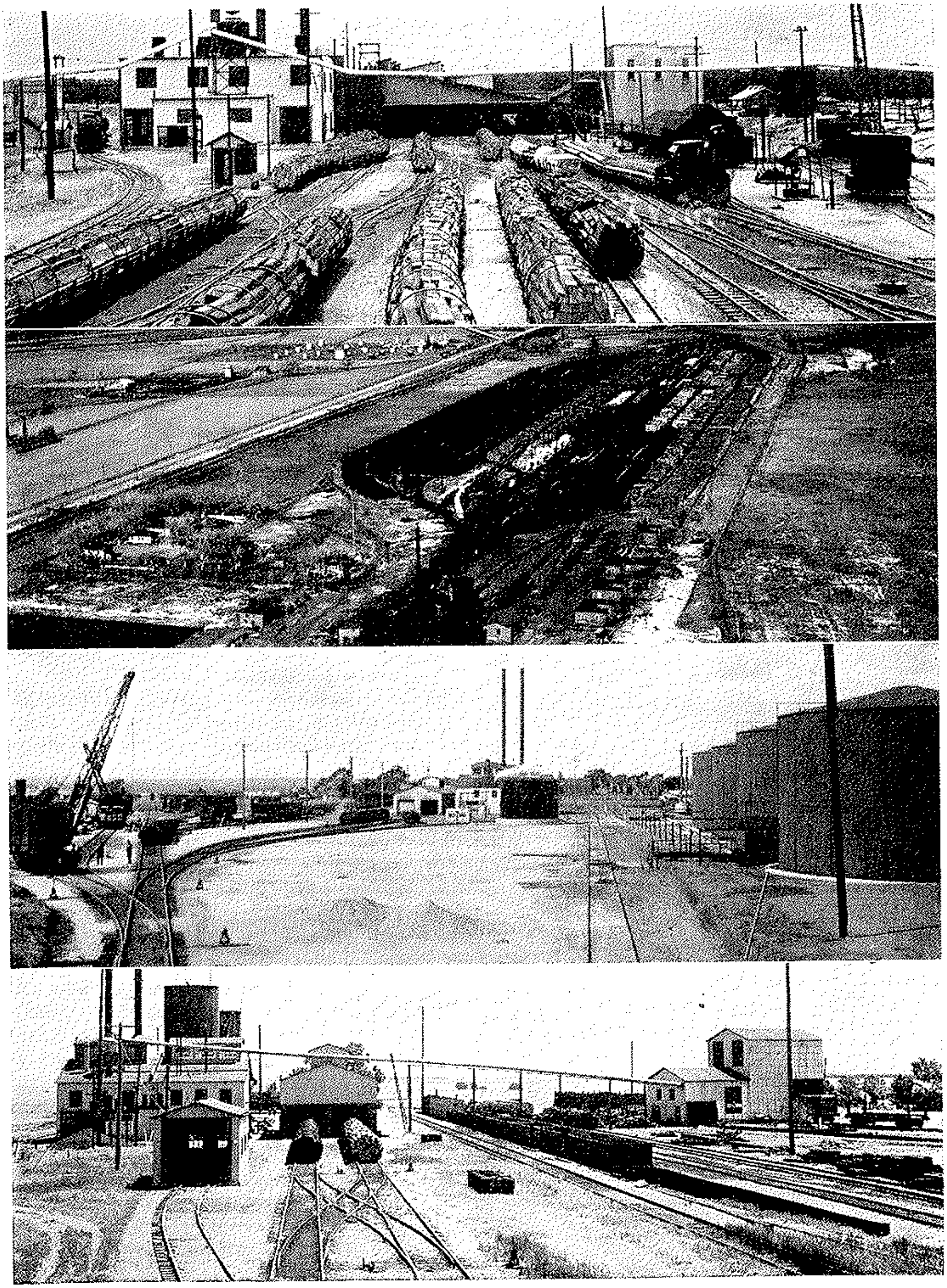
Treating plant operations begin with the unloading of cross ties, switch ties, bridge timbers, piles and miscellaneous lumber of all kinds onto plant yards for air-seasoning prior to treatment. All stacking is done according to prearranged scientific methods. The seasoning period varies from four to eighteen months depending on the class of material.

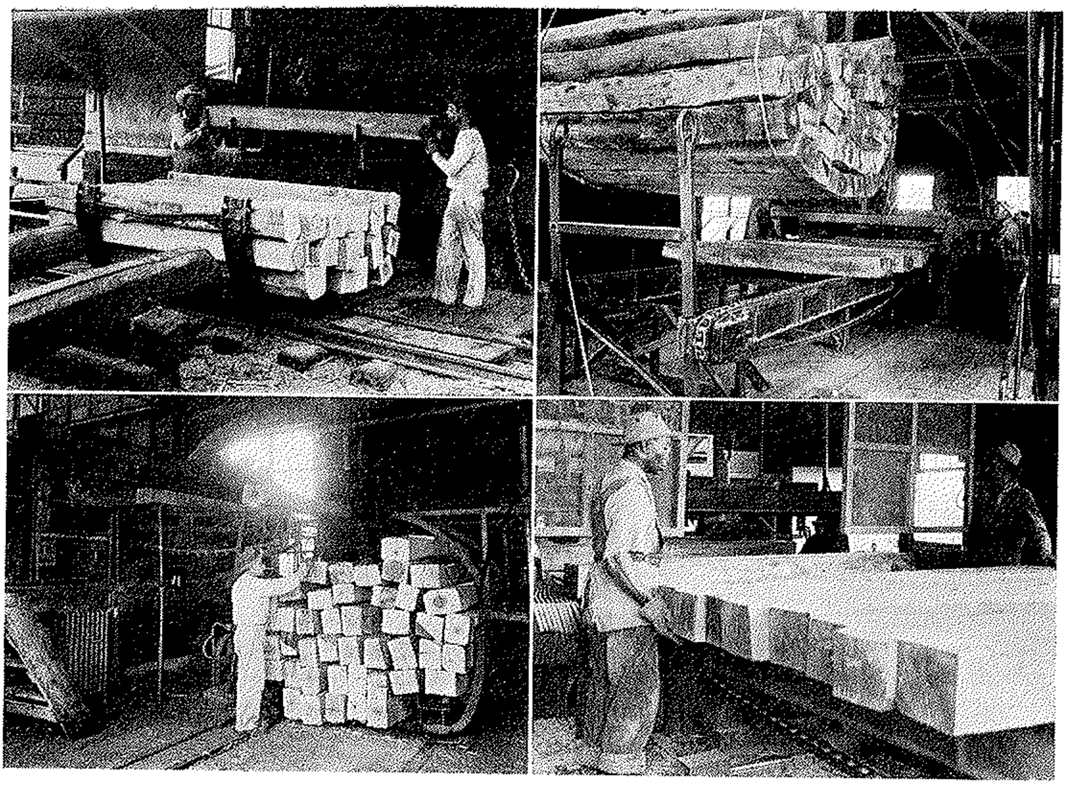
When seasoned, cross ties are loaded on yard cars and moved to the tie boring and adzing machine for trimming to length, adzing for tie plates, boring for spikes, and branding on the ends with letters and figures representing the kind of wood, weight of rail for which bored, grade, kind of treatment and year. Bridge timbers and lumber are moved on yard cars to the woodworking machinery (sawmill) where they are trimmed, sized, bored, and otherwise preframed for intended use. Preframing bridge and other material adds to the service life and also minimizes construction costs of timber bridges and wooden structures.

Trimmings from ties are conveyed to a pulverizer and from there, together with shavings and sawdust from the various machines, are blown to the boiler house where a large funnel-shaped separator

SANTA FE SYSTEM TIMBER TREATING PLANTS

Top—Somerville, Tex.
Second—Albuquerque, N. M.
Third—National City, Cal.
Bottom—Wellington, Kan.





All ties used in Santa Fe tracks are bored for spikes, adzed for tie plates, trimmed and branded (upper left). Upper right—After the ties have been thoroughly air-seasoned, they are put through the adzing and boring machine. Lower left—Ties having been trimmed, bored, adzed and branded, pass from the machine on power-driven, power-adjusting out-going conveyor and are loaded on to trams. Lower right—As the ties come from the boring and adzing machine they are loaded on tram cars and moved to the treating cylinders.

called a "cyclone" separates the air from the pulverized trimmings, shavings and sawdust, dropping the latter into the boiler furnaces or storage bins. Use of wood refuse under the boilers reduces materially the amount of fuel it is necessary to purchase.

Plant grounds are free of extraneous materials. Sprinkler systems and systematic fire patrol are among the elaborate fire precautions.

When untreated material has been machined it is loaded onto tramcars which form a train the length of which is governed by the length of the retort or treating cylinder. The train of tramcars is rolled into the cylinder. The latter is closed, bolted, and treatment of timber is gotten under way.

Before outlining Santa Fe timber treating methods it is best to review the history of wood preservation. Such a review places the Santa Fe in the front ranks of this worthy science.

The primary objective of wood preservation is to increase the service life of the various forms of wood in service, thus decreasing the ultimate cost and avoiding the need for frequent replacements in permanent and semipermanent construction. Both labor and material constitute the total of such savings. At the same time a very considerable step has been taken toward conservation of national forest resources.

Mercuric chloride was used for protecting wood against decay as early as 1705; copper sulphate in 1767. The treatment of wood with mercuric chloride became known as Kyanizing, after the first patentee. In 1838, Sir William Burnett obtained a patent for the immersion of wood in zinc chloride solution in open tanks. In 1847, a pressure process was devised, the forerunner of modern Burnettizing treatment. John Bethell was granted a patent for the injection of creosote into wood under pressure in 1838.

The Bethell process met with outstanding success and is the foundation of most modern methods of wood preservation. The modern Bethell or so-called "full-cell" process makes exclusive use of creosote, creosote-coal tar solution, creosote-petroleum solution and certain other creosote mixtures.

In its early years the Santa Fe was not so fortunately located in relation to availability of cross ties. The Santa Fe ran across plains rather than through timbered country. Transportation was a considerable factor in the cost of Santa Fe ties and timbers.

The Santa Fe management early became interested in some method of tie preservation which would lengthen the life of ties and timbers, compensating for the cost and inferior quality of material available. Investigations were encouraged by the high cross tie renewal rate and the heavy demands incident to construction of new lines —all of which bid fair to exhaust domestic timber resources if rates of consumption were not reduced.

The Santa Fe's experience with treated timber dates back to 1875, when piling for the construction of a Santa Fe trestle across Galveston Bay was creosoted at a treating plant built by a Mr. Trundy at the west end of the shops at Galveston.

A few hundred ties, purchased from a wood preserving works in St. Louis, treated by the Wellhouse process, were placed in Santa Fe tracks near Topeka and LaJunta in 1881 and 1882. That process had been introduced in 1879 by Wellhouse and Hagen. It provided for the treatment of wood first with a combination of zinc chloride and glue which was followed with the pressure application of a tannic acid solution.

The first Santa Fe timber treating plant was erected at Las Vegas, N. M., in 1885. During that year a total of 111,503 ties were treated. Somerville Tex., operations began in 1897, the Santa Fe taking over the plant there in 1905 and erecting a new plant in 1906. In 1898, the Santa Fe opened a treating plant at Bellemont, Ariz. The Albuquerque plant was built in 1908 taking the place of the Las Vegas and Bellemont plants. The National City plant was built in 1924 and the Wellington plant in 1930.

From 1885 onward, the treatment of ties (and lumber and pilings after 1894) annually showed an upward trend. In 1900, a total of 2,645,219 ties were treated. That average was fairly maintained each year until 1929 when an all-time high of 5,090,359 ties were treated at Santa Fe plants.

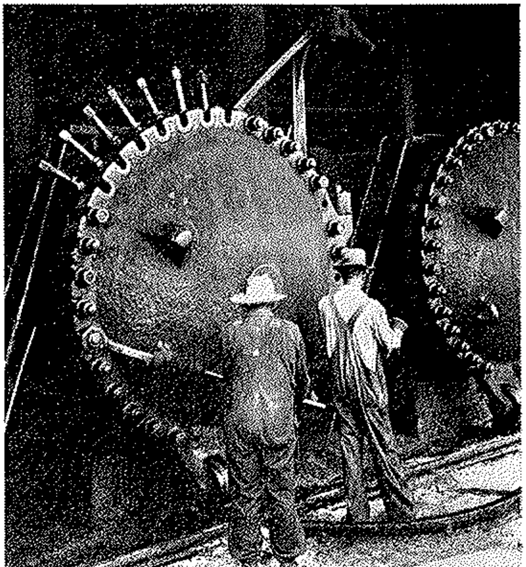
Classes and total material treated by and for the Santa Fe from 1885 to and including December, 1946, includes:

	Cubic Feet
129,602,949 cross ties	415,335,203
175,545,871 f.b.m. switch ties	14,557,777
427,456,454 f.b.m. lumber ...	35,554,827
18,639,151 lin. ft. piling	17,302,452
Miscellaneous	6,025,190
Total, cubic feet	488,775,449

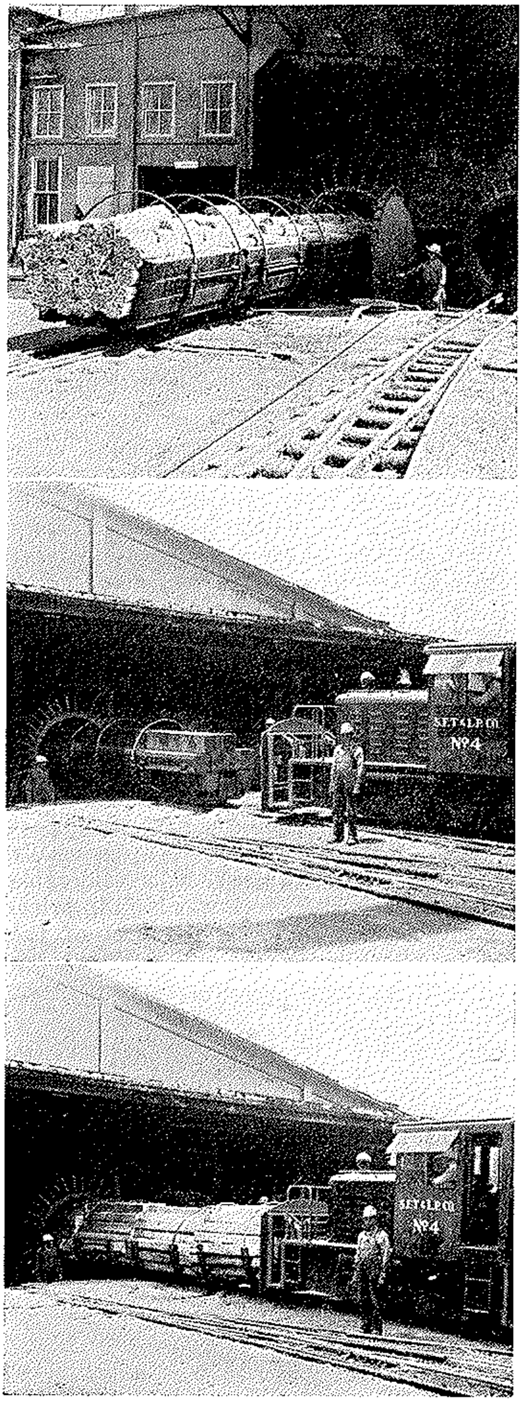
One may visualize the enormity of that treating task and the tremendous savings in operating costs—in addition to the conservation of national timber resources. In 1900, the life of a cross tie was nine years. Today, the average service life of Santa Fe main track ties is twenty-two years. For all classes of track it is twenty-seven years. Some test groups give promise of thirty years or more of average life.

The Santa Fe used the Wellhouse process at its Las Vegas, Bellemont and Somerville plants at various early periods after which change was made to the Burnettizing or straight zinc chloride process. Zinc chloride still is used in wood preservation, largely for special uses and the treatment of wood which is not used in contact with the ground.

The pressure treatment of wood with creosote began to assume a position of major importance the latter part of the past century. Such treatments were generally successful but required a considerable amount of creosote which was high in price. That brought into being the first of the



After the charge is in the cylinder, the "bridge" is pulled away, the cylinder door closed and bolted, the pumproom engineer is then given the signal to start the "run."



A charge of tie plugs goes into the treating cylinder (top). Pulling a charge of treated bridge caps from treating cylinder (middle). Bottom picture shows plant charged with first-class hewn Southern pine ties.

"empty-cell" processes, the Rueping, named after Max Rueping who obtained a patent in 1902. A second empty-cell process was patented by C. B. Lowry in 1906.

Both the Rueping and Lowry processes provide for the impregnation of wood with a relatively large volume of creosote to obtain maximum depth and uniformity of penetration. The processes, however, withdraw a large volume of oil, leaving a very much smaller net retention of the preservative in the wood. The withdrawal is accomplished by air in the wood cells (originally at atmospheric pressure in the Lowry process and at higher than atmospheric pressure in the Rueping process, in which air is forced into the wood cells under pressure), which expands upon release of the pressure used to force the preservative into the timber, assisted by the creation of a vacuum in the retort after the injection of the preservative is complete and the preservative removed from the retort.

The Santa Fe was the first, not only in this country but in the world, to adopt the Rueping process, the first charge so treated coming from the cylinders of the Santa Fe's Somerville treating plant on February 22, 1906. It was four years later that Germany, where Rueping developed the process, began to use it commercially.

The Santa Fe has used the Rueping process for the treatment of ties, switch ties, signal poles, crossing plank and various other forms of wood treated with creosote or creosote-petroleum mixtures, from 1906 to the present time. It is the Santa Fe's standard process for ties, switch ties, and other materials where the net retention of preservative is limited.

Economy in the use of creosote brought about admixture of coal tar, water-gas tar and petroleum, particularly for cross tie and switch tie treatment. The Santa Fe was the first railway to adopt creosote-petroleum and it has been the Santa Fe standard preservative since 1923.

The Santa Fe began treating its western pine cross ties and switch ties in 1909 with a mixture of 30 per cent creosote and 70 per cent petroleum, with a net retention of 10 to 12 pounds of mixture per cubic foot of timber. In 1912, the mixture was changed to 50 per cent creosote and 50 per cent petroleum, with a net retention of seven pounds per cubic foot. A total of 1,000,000 western pine cross ties were so treated at Albuquerque during 1909-1914. Use of creosote was limited during World War I and until 1923, due to scarcity. After

1923, its use broadened. Sixteen American railways today use creosote-petroleum solutions. During 1945, a total of 68,450,072 cubic feet of wood were so treated, including 41.3 per cent of all treated cross ties.

In addition to general instructions issued by the manager of treating plants, each treating plant prepares bulletins specifying type of treating mixture to be used for specified items, amount of mixture to be absorbed by the woods, air pressure, preservative pressure period, time final vacuum started and broken, time or length of treatment and other details. That enables intimate control of individual treatments at all times.

The Santa Fe's general specifications for the preservative treatment of timber are segregated between those covering Pacific Coast Douglas fir and those covering other woods treated by the Santa Fe. This is necessary because generally lower and longer pressures are used in the treatment of Douglas fir and there are certain other differences in the treating procedure not used in the treatment of other woods treated by the Santa Fe.

The petroleum oil and coal-tar creosote used in an admixture as a wood preservative by the Santa Fe must meet specifications as approved by the chief engineer system. Creosote must be a distillate of coal-gas or coke-oven tar. Oil must be a petroleum product, preferably of asphalt base.

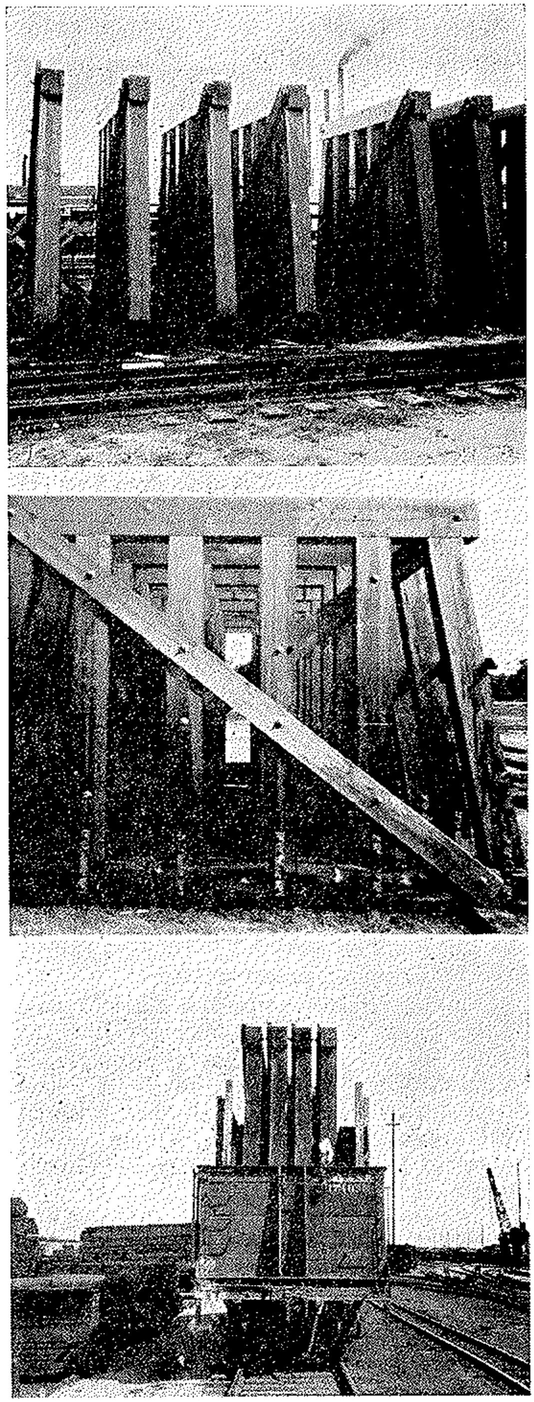
Preservatives used by the Santa Fe are: Coal tar creosote; a solution of 50 per cent creosote and 50 per cent petroleum residuum by volume; a solution of 45 per cent creosote and 55 per cent petroleum residuum by volume; a solution of 30 per cent creosote and 70 per cent petroleum residuum by volume.

War conditions have prevented the securing at all times of creosote meeting Santa Fe specifications—that having residue of not more than 20 per cent boiling above 355° C. When it is necessary to use creosote having higher residue, a correspondingly greater percentage of creosote is used.

If the cylinder is filled at atmospheric air pressure, the treating process is that known as Lowry. If initial air pressures higher than atmospheric are used, the process is that known as Rueping.

Treatment of timber other than Pacific Coast Douglas fir:

Manner of Treatment—The material shall be treated by an empty-cell process whenever practicable, to obtain as deep and uniform penetration as possible with the



Bridge timbers. Not only are bridge timbers framed before treatment, but in many instances frame bents are assembled at the plant after treatment, and shipped ready to place in the bridge.

retention of preservative stipulated. Material shall be treated by the full-cell process only when the maximum net retention is desired and where pressure is held to refusal, or when the stipulated retention is greater than can be obtained by the use of an empty-cell process. The ranges of pressure, temperature and time duration shall be controlled so as to get the maximum penetration by the quantity of preservative injected.

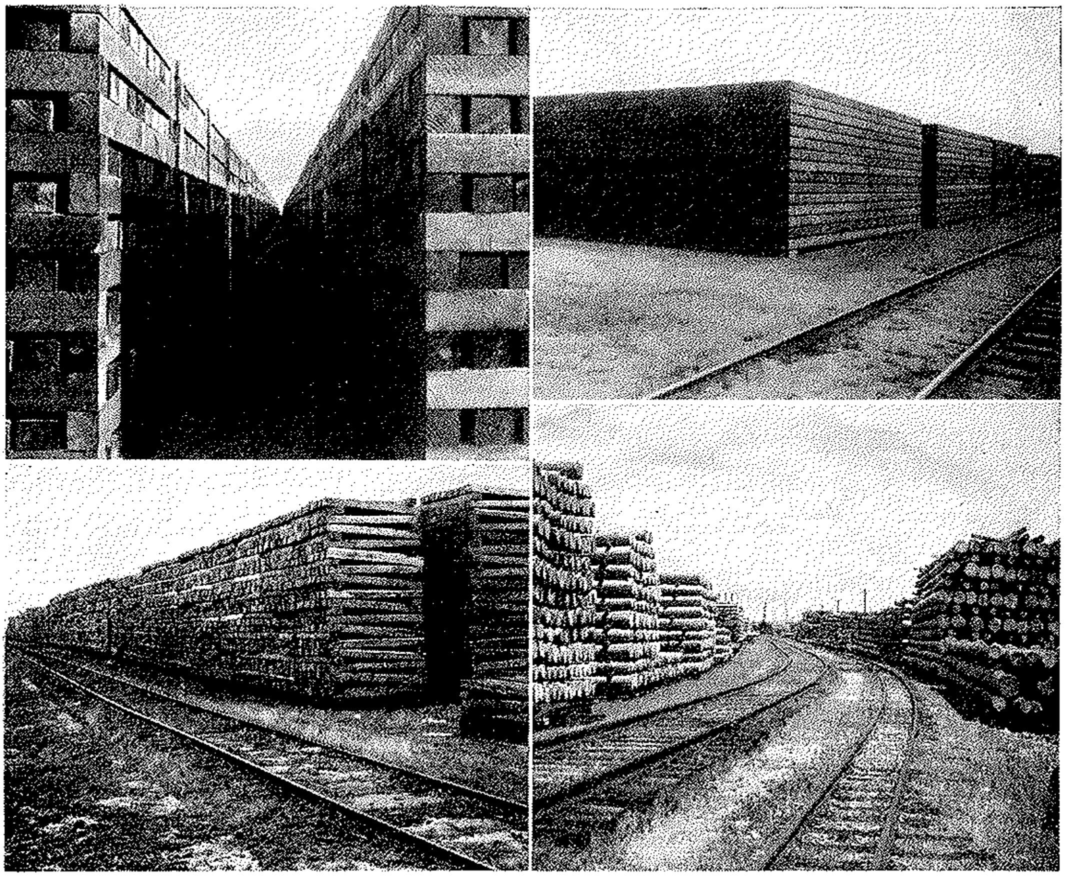
Standard processes—Empty-cell—Lowry and Rueping. Material shall be subjected to atmospheric air pressure or to higher initial air pressure of the necessary intensity and duration. The preservative shall be introduced until the cylinder is filled, the air pressure being maintained during the filling operation. The pressure shall be raised to not more than 200 pounds per square inch. Material shall be held under pressure until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by ejection of surplus preservative from expansion of the air and by a quick, high vacuum. The temperature of the preservative during the entire pressure period shall be not more than 210 degrees F., but shall average at least 190 degrees F. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

Full-cell—Bethel—Material shall be subjected to a vacuum of not less than 22 inches at sea level for not less than 30 minutes. The preservative shall be introduced until the cylinder is filled without first breaking the vacuum. Pressure shall be raised to not more than 200 pounds per square inch. The material shall be held under pressure until there is obtained the volumetric injection that will insure the stipulated retention or until the wood is treated to refusal. The temperature of the preservative during the entire pressure period shall be not more than 210 degrees F., but shall average at least 190 degrees F. After pressure is completed, the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative.

Treatment of Pacific Coast Douglas fir timber:

Manner of treatment—Following the conditioning period, the material shall be treated by an empty-cell process whenever practicable, to obtain as deep and uniform penetration as possible with the retention of preservative stipulated. Material shall be treated by the full-cell process only when the maximum net retention is desired and where pressure is held to refusal, or when the stipulated retention is greater than can be obtained by the use of an empty-cell process. The ranges of pressure, temperature and time duration shall be controlled so as to get the maximum penetration by the quantity of preservative injected.

Standard processes—Empty-cell—Lowry and Rueping. Material shall be subjected to atmospheric air pressure or to higher initial air pressure of the necessary intensity and duration. The preservative shall be introduced until the cylinder is filled, the air pressure being maintained during the filling operation. The pressure shall be raised to not more than 150 pounds per square inch. Material shall be held under pressure until there is obtained the largest practicable volumetric injection that can be reduced to the stipulated retention by ejection of surplus preservative from expansion of the air and by a quick, high vacuum. In no case, however, shall the period of maximum pressure exceed 12 hours for rectangular material and 16 hours for round material. The temperature of the preservative during the entire pressure period shall be not more than 210 degrees F., but shall average at least 190 degrees F. After pressure is completed the cylinder shall be emptied speedily of preservative, and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative. Or, after pressure is completed and before removal of the preservative from the cylinder, the preservative surrounding the material may be reheated to a maximum of 220 degrees F., either at atmospheric pressure or under vacuum, the steam to be turned off the heating coils immediately after the maximum temperature is reached. The cylinder shall then be emptied speedily of preservative and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative. At the completion of treatment, material may be cleaned by a final steaming at not more than 240 degrees F., for not more than 30 minutes.

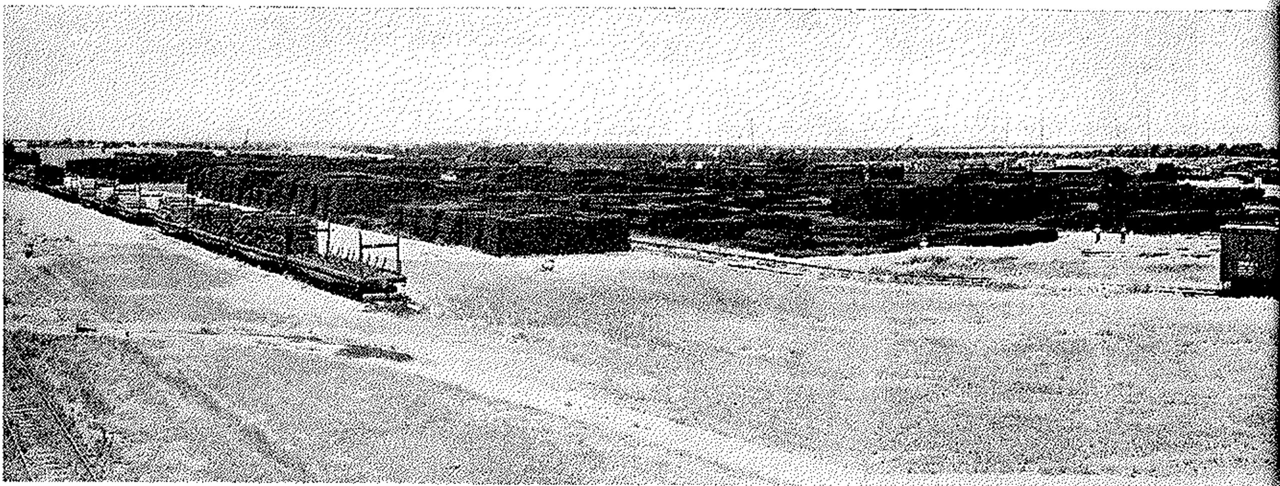


Neatness prevails. Upper left—View down on alley between stacks of Douglas fir cross ties at National City treating plant. Upper right—This plant also furnishes the stringers and caps for the system, as well as most of the bridge timbers used on the Coast Lines. Lower left—Untreated Southern pine ties stacked for seasoning, Somerville treating plant. Lower right—Southern pine poles and piles stacked for seasoning at Somerville plant.

Full-cell—Bethel—Material shall be subjected to a vacuum of not less than 22 inches at sea level for not less than 30 minutes, either before the cylinder is filled or during the period of heating under vacuum. If not already full, the cylinder shall then be filled without first breaking the vacuum. The pressure shall be raised to not more than 125 pounds per square inch. The material shall be held under pressure until there is obtained the volumetric injection that will insure the stipulated retention, or until the wood is treated to refusal. In no case, shall the period of maximum pressure exceed 12 hours for rectangular material and sixteen hours for round material. The temperature of the preservative during the entire pressure period shall be not more than 210 degrees F., but shall average at least 190 degrees F. After pressure is completed the cylinder shall be emptied speedily of preservative and a vacuum of not less than 22 inches at sea level created promptly and maintained until the wood can be removed from the cylinder free of dripping preservative. At the completion of treatment, material may be cleaned by a final steaming at not more than 240 degrees F., for not more than 30 minutes.

Ties and timbers of all kinds are treated to prevent decay and to prolong the useful service life. In many kinds of timber, the effective treatment is in the sapwood only and in all kinds of timber the heaviest treatment is nearest the surface. Care must be used, therefore, in handling treated timber so that protective coating will be damaged as little as possible; that edges will not be split and thus expose untreated wood. Heavy timbers, piling and similar bulky articles are preferably handled with a crane or derrick.

All treated wood is stacked as compactly as possible. Too rapid drying tends to cause excessive checking and splitting. Proper stacking retards evaporation and timber is



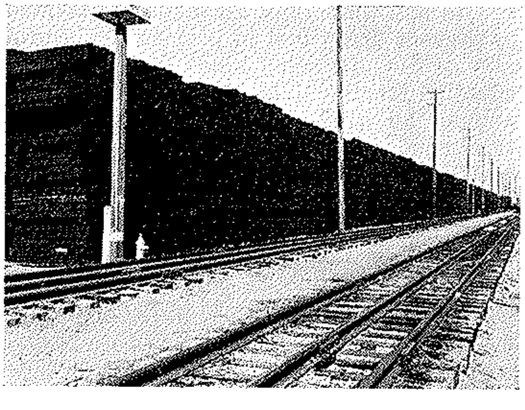
Panorama of Wellington treating plant yard. At left are treated ties stored

in a better condition when put in service. In some instances, it is desirable to cover the top layer of the stack with about two inches of dirt, sand, or cinders, or second-hand or scrap lumber, to prevent warping and sun-checking. Grass and weeds are cleaned away from stacks.

The Santa Fe and Northern Pacific railways installed the first tie boring and adzing machines used in the United States. The Santa Fe placed two machines in operation in 1911, one on redwood and cedar ties at National City (prior to the erection of the treating plant at that tie storage point in 1924); the other machine was placed at Somerville for adzing and boring southern pine ties.

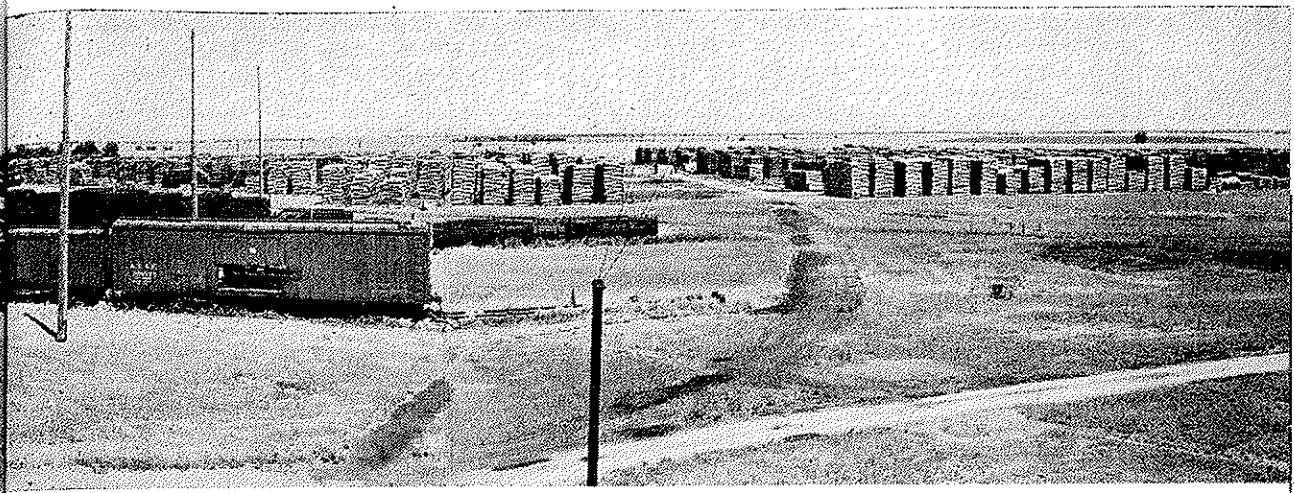
Adzing provides smooth, even-bearing surfaces for tie plates. The latter do not have to find their bearing by crushing down or wearing away the inequalities in the top surface of the tie. Adzing before treating prevents exposure of untreated interior of poorly penetrated ties. Preboring prevents crushing and tearing of the wood by spikes. The wood fibers are not bent by the spike on driving to as sharp an angle as when not prebored, and the tie is more resistant to side thrust on the spike, retarding spike killing. The preservative enters the prebored holes obtaining good absorption in the vulnerable railbase section of the tie, protecting from decay around the spikes and increasing resistance of the wood to spike killing.

For the past twenty years, practically all Santa Fe cross ties have been prebored and preadzed, trimmed and branded prior to treatment. All treating plants are equipped with special machinery for that purpose,



These treated pine ties are handled from trams to stacks by locomotive crane and straightened on stack by crew of crane.

Cross ties treated at National City are from the Douglas fir mills in the Northwest and are stacked for air-seasoning as are the bridge timbers.



to await shipment as required; at right, untreated ties stacked for seasoning.

Santa Fe timber treating personnel having co-operated with the manufacturer in the improvement and development of those machines.

Incising consists in cutting holes in the surface of the wood to be treated so that more uniform penetration of preservative may be obtained. The Santa Fe does this according to specifications, particularly to Douglas fir. The incisions are made to a pattern which provides for the spacing of the incisions ¾ inch across the grain of the wood in rows 2.35 inches apart lengthwise of the grain, but staggered 7/32 inch so that every fifth row of teeth are in the same line lengthwise of the grain. Incising is of value only for the treatment of woods that are resistant to side penetration but treat fairly well along the grain.

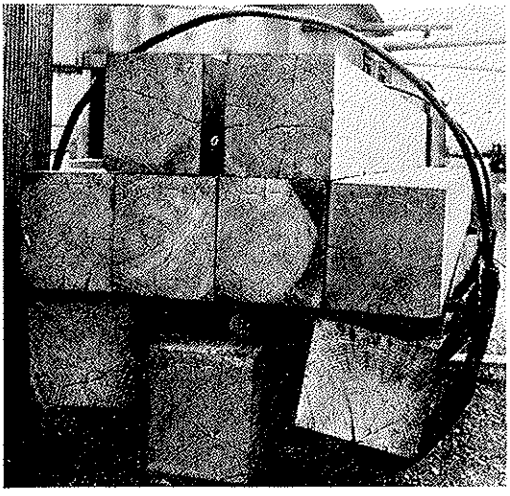
All Douglas fir stringers, caps and other bridge lumber used by the Santa Fe are incised. The Santa Fe was one of the first railways to incise its Douglas fir bridge material; and to all purposes, the first to incise 100 per cent of its Douglas fir bridge lumber three inches or more in thickness. Material two inches in thickness or less is not incised.

Preframing is the process of shaping all timbers and wooden parts used in the erection of a bridge or other construction. That includes boring, sawing, dapping, planing, and other operations producing exact dimensions needed for the finished structure. That enables assembly where used without danger of exposed untreated wood areas which would decay and shorten the life of the structure.

The Santa Fe was one of the first railways to adopt preframing as standard practice. Standard plans number the various sizes and borings of stringers, caps and other bridge timbers and furnish the detail necessary to completely preframe them at the treating plant prior to treatment. Frame bents are milled, treated and shipped either knocked down or bolted together, depending upon the height of the bents.

In addition to bridge material, standard black gum planked crossings, platform material, sign-post bases, signal poles, corner posts, and a large volume of miscellaneous material are preframed at Santa Fe treat-

Portion of the experimental section at Argentine, Kan., eastward and westward main tracks, one of 57 tie tests on the system in which 977,317 cross ties are in service and under observation.



Bridge timbers are sized and bored before treatment. Here is a tramload of 14x15½x14 bridge caps stamped on end to indicate the size and boring as shown by standard plans and year in which treated.

ing plants. That not only increases the service life of such material, but substantially reduces construction labor in the field. Preframing methods followed by the Santa Fe enable the production of as nearly perfect a bridge as it is humanly possible to construct of such materials.

The reworking at the treating plants of salvaged secondhand timber and lumber and the reclaiming of a large percentage of reusable material has not only effected an economy by reducing the outlay for new lumber, but in many instances in the past few years, has made possible the completion of structures which could not have otherwise been built because new lumber was unobtainable. The favorable location for reclaiming secondhand lumber is at the treating plants where woodworking machinery is available and reclaimed lumber can be retreated after it has been reworked, if desired.

The various treating plants receive orders for all classes of materials from the Santa Fe's store department. Shipments are made in line with instructions contained in those orders. In collaboration with the store and purchasing departments, the timber treating department maintains at plants and at specified locations, stocks of proper kinds and quantities of all classes of ties, timbers, piles, switch ties, and miscellaneous lumber.

The timber treating department performs a very definite service. It has enabled the Santa Fe to pioneer in the field of timber cross tie preservation, of value not only to the Santa Fe but other railways as well. Santa Fe tie treating specifications and practices are based on the results of its own experiments and investigations. Information is continually being developed. Some plants have a "graveyard" where sticks and poles and other wood specimens are planted or otherwise exposed after special treatments. It takes years to prove or disprove the value of a given treatment.

Santa Fe adopted preservative methods have borne fruit. This is indicated by the reduction in tie renewals per track mile, the weighted average number of ties inserted annually during the five-year periods ending; 1909, 266 per mile; 1914, 228; 1919, 173; 1929, 136, and 1939, 101 per mile. In the twenty-year period 1927-1946, the average tie renewals in some 20,000 miles of Santa Fe track was 102 per mile per annum.

Those figures attest better than words to the value of scientific timber treatment and the effectiveness of the Santa Fe's adopted methods.

Engineering department officers are prominently identified with leading associations in this nation which are concerned with scientific timber preservation. The manager of treating plants is a member of the tie and wood preservation committees within the American Railway Engineering Association and is a member and past president of the American Wood Preservers' Association, having served for many years on the executive committee of the latter organization.

The Santa Fe early experimented with various foreign hardwoods in its search for wood suitable for cross ties and available in sufficient quantities to justify consideration as a source of supply, it being feared by all railways that domestic timber resources would prove inadequate.

In 1907, the manager of the Santa Fe's tie and timber department, E. O. Faulkner, visited the Hawaiian and Philippine Islands, China, Australia, Manchuria, Korea and Japan. Later, a second representative was sent to make a further study of timber supplies in Hawaii, Mexico, Venezuela, Cuba and Japan.

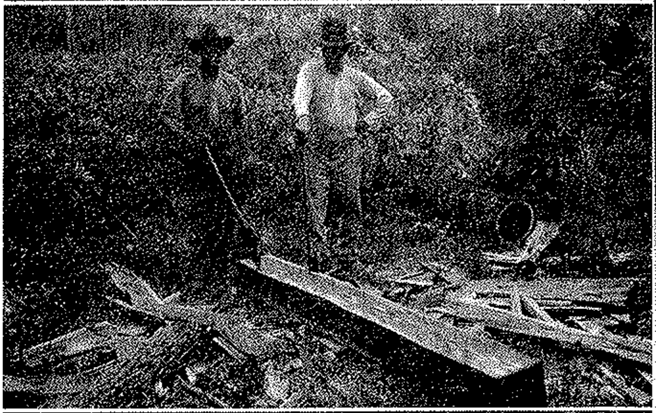
Between 1907 and 1913, approximately 3,500,000 oak ties were imported by the Santa Fe from Japan and installed untreated on the Coast Lines. Subsequent tests and observation developed that Japanese timber did not merit further consideration as a source of cross tie supply. Service life ranged from eight to fifteen years,

HEWN TIE MAKING IN EAST TEXAS

"Bedding in" a red oak tree, which directs the fall of the tree. . . . Tree is down and first cross tie length has been sawed from trunk. . . Hewing with broad axe. . . . After sides have been "slabbed off" with wedges, maker "score hacks" with axe. . . . The red oak tie is finished. . . . The makers, Buck and Jim. . . . Ox team hauls nine ties to station tie yard. . . . Unloading ties from truck for inspection.





Sectional panel crossing manufactured from a surplus of small gum ties at the treating plants.

The sapling, or "graveyard" test at Somerville, an accelerated test which shows results in months.

failure being due chiefly to decay and in part to splitting and checking.

Between 1907 and 1912, more than one million eucalyptus ties were imported from Australia and installed untreated on the Santa Fe's Western and Coast lines. That importation followed an experiment in 1906 wherein the Santa Fe planted 1,500 acres to eucalyptus trees near Del Mar, Cal., which did not prove practicable.

The service life obtained from the Australian eucalyptus ties ranged from six to seventeen years, averaging less than ten years. Some of the species which gave best results in Australia, gave poorest service in Santa Fe tracks. Most of the Australian ties failed because of splitting and checking, developing into the condition known as "shattered".

The Santa Fe's study of foreign woods for tie purposes included ohia wood from Hawaii. Beginning in 1908, considerable quantities of ohia ties were imported and installed in various tests at different locations on the Santa Fe system lines. The average of all ohia tests disclosed a life of approximately nine years. Their use was abandoned.

Generally, foreign hardwoods did not provide the same favorable results under conditions in this country as they did under conditions peculiar to their native countries. While cost was not the factor which encouraged the Santa Fe to seek a source of tie supply abroad, it had to be considered in comparing the results obtained from foreign and from domestic woods.

Chief engineer system standard plans designate the type and class of cross tie assigned to various sections of track throughout the Santa Fe system lines. Those designations usually are divided between class "A" and class "B" track, the former embracing all main lines and important branch lines; the latter embracing other branch lines.

Hardwood ties are standard for all main track curves of one degree and over in class "A" and class "B" tracks. They are also standard for sharp curves on industry and side tracks and for important leads in yards; also for main track tangents and all curves for designated class "A" mountain territories--Trinidad-Raton, Glorieta-Lamy, Ash Fork-Williams (ascending eastbound), Prescott-Skull Valley, and Victorville-Highland Junction (ascending eastbound or westbound).

Standard plans also include adzing, boring, grooving and stamping operations. That includes all dimensions—tangents and curves and wide gauge. Class of tie is stamped thereon as well as treatment heretofore described. When inserted in track, a dating nail indicating the year is driven into all Santa Fe ties. Round head dating nails are used for treated ties, square head for untreated ties, and five-sided for second-hand treated ties.

Timber treating department inspectors make annual inspection and check of ties in test sections and out-of-face tests. At as many locations as time will permit, where new rail is being laid, track surfaced, or for any reason large numbers of ties are being removed from track, inspectors ascertain and tabulate causes of failures in old ties removed, and closely observe all practices and equipment which affect ties, being sure that all newly adzed areas are mopped with hot creosote-petroleum mixture and treated tie plugs correctly driven.

That careful inspection is extended to the installation of test treated gum and other planked street crossings so that recommendations may be made which will prolong their service life. Santa Fe bridges in which treated timber is used are carefully observed from the preservation angle, and in many instances detailed examination of timbers is made in connection with the repairs or renewals of timber bridges. Certain test bridges are inspected annually.

The Valuation Department

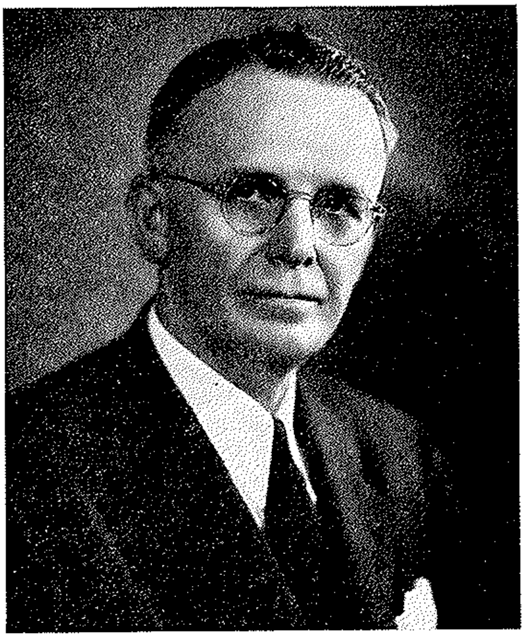
THE valuation section of the Santa Fe's engineering department, under the supervision of system valuation engineer, has for its prime responsibility the Santa Fe's compliance with orders of the Interstate Commerce Commission in connection with Section 19a of the Interstate Commerce Act of March 1, 1913. Section 19a of that act requires all common carriers to render specified reports to the Commission, informing the latter of physical changes in the common carrier properties, including not only the property used in common carrier operations but also other miscellaneous physical property owned by the carrier, the costs associated therewith for additions and retirements, and the yearly changes in price levels and values of railway properties.

The system valuation engineer is assisted in that considerable task by an engineer of inventories and a cost engineer, located at Chicago, and by a valuation engineer and staff located on each of the Santa Fe's four grand operating divisions, each of whom reports jointly to the grand division chief engineer and to the system valuation engineer.

In matters pertaining to valuation of shop machinery and equipment, the system valuation engineer has close co-operation with the mechanical department through the mechanical valuation engineer at Topeka. In land valuation matters he gets assistance from right of way agents who report to chief engineers on the grand divisions.

The Congress, through the Interstate Commerce Act of March 1, 1913, required the Interstate Commerce Commission to: "—investigate, ascertain, and report, the value of all property owned or used by every common carrier, subject to the provisions of this part, except any street, suburban, or interurban electric railway which is not operated as a part of a general steam railroad system of transportation."

Development of American railways had been rapid, so rapid that prior to the Commission's survey, an up-to-date inventory of railway properties, and a determination of their value, was not available. Construction



F. B. Baldwin, valuation engineer system, with headquarters in Chicago.

and improvement records not only were meager but were widely scattered. There were no uniform accounting regulations. Changes in railway ownership were frequent.

The Commission's inventory involved the listing and measurement of all bridges, buildings, tracks, telegraph lines, power plants, tunnels and roadway facilities; and the listing of all engines, cars and machinery of all kinds (see mechanical valuation engineer) and an inventory of all existing records, both accounting and historical.

In addition to inventories of the fixed and movable railway properties, there was involved an examination of land records to determine the extent of the railway's ownership or use of land for right of ways and terminals; the determination of costs of railway construction as of the date of the inventory; and all facts with respect to organization, operation and corporate relationships.

The inventory task required ten years. The Santa Fe furnished a pilot and necessary records for each I. C. C. party and facilitated the movement of those government forces over its lines, assisting with the inventory. All Santa Fe property, including roadbed, track, structures and land, was covered.

During the inventory period, the valuation department made a complete check of the Commission's inventory, advising the government forces of omissions and errors. The valuation department also furnished information required under the various I. C. C. orders (such as schedules showing area, date acquired and original cost of all land owned by the carrier), and prepared numerous cost and valuation studies. That assistance amounted substantially to an independent valuation of the property and was of use in pointing out instances where values placed by the I. C. C.'s valuation bureau were considered inadequate.

As a result, a large percentage of Santa Fe claims for increase in value was satisfactorily adjusted in conference with the bureau's district office. Other claims were adjusted at an informal conference held with the bureau of valuation in Washington. A few claims were formally presented to the I. C. C. by the Santa Fe's law department.

To enable the bureau of valuation to perpetuate the value of inventoried railway properties, the carriers were required, under the provisions of I. C. C. Valuation Order No. 3, to report annually all additions and retirements made since inventory date. The valuation engineer does that reporting for the Santa Fe system lines. The Los Angeles, Amarillo, Topeka and Galveston valuation engineers transmit completion and other reports to Chicago for that purpose. Grand division valuation engineers retain copies of completion reports, field closeout notes, and other basic data. Those are filed for reference purposes and are readily accessible to I. C. C. examiners when they call to check order No. 3 returns on each Santa Fe grand division.

Another requirement of the Interstate Commerce Act is that the Commission keep itself informed of current changes in costs and values of railway properties. That has been interpreted to mean that the Commission will collect data currently to show the changes or trends in costs of the construction of railway facilities. Carriers are required to report annually to the Commission the cost of the more important items such as rails, ties, ballast, lumber and other construction materials; also to furnish evidence of labor costs as reflected by contracts for performing different kinds of construction. Joint committees of railway valuation representatives co-operate with the bureau of valuation on suitable trends in the cost of railway construction.

In recent years, the railways have been forced to pay more attention to equitable adjustments of taxes levied by state commissions and other tax authorities. That has required more detailed information regarding the physical property of the railways within each taxing district. In some states, tax laws have been modified to require a great amount of detail, broken down by counties, school district, drainage district and other subdivisions where separate tax rates were needed for local improvements. The work of getting satisfactory adjustments and of furnishing the details required by the modified tax laws has been aided, to a great extent, by the system of records which have been built up by the valuation department.

Those records also enable the valuation department to furnish, currently and readily, annual statements of costs and values of the Santa Fe's physical property, necessary for the property tax adjustments and for insurance schedules, depreciation schedules on road and equipment, and for accounting and income tax purposes.

The valuation department also furnishes numerous statements of quantities, costs and appraisals of land and improvements involved in leases, purchases, sales, mergers, lawsuits, traffic agreements and retirements, abandonments and other matters.

The recording of property changes on individual facility records—track, bridges, buildings, signal and telegraph, grade crossings, protection work, and right of way fence—provides a record of the I. C. C. inventory and of all changes made since valuation date. Main track is recorded by individual miles and side tracks are recorded by individual tracks and station location. Buildings are recorded by individual structures at each station. Bridges and grade crossings are recorded by individual facilities and mile post location. Protection work and right of way fence is recorded by individual miles. Signal and telegraph work is recorded by valuation sections with charts from which the units and cost for any specified location readily can be obtained.

Those records are used continuously in the furnishing of retirements (out of serv-

VALUATION ENGINEERS

H. A. Shinkle
Eastern Lines

J. W. Higgins
Western Lines

G. B. Stearns
Coast Lines

J. N. Olson
Gulf Lines

ice) and have greatly facilitated and reduced the cost of that work. They have also proven of value in connection with rate hearings, joint facility contracts, and all other work where investment cost or estimated value of the company's property at any specified location or within any specified limits is required.

When land values are required for short term leases, the valuation engineer usually is in a position to furnish them from office records. With long term leases, special field investigations often are necessary before accurate values can be furnished. The valuation department furnishes values for establishing rental rates on structures or portions of structures leased by the Santa Fe to outside parties, and values for proposed sale of structures no longer required for Santa Fe purposes.

Special work of the valuation department includes requests from other Santa Fe departments for value, cost, statistical information or historical data required for specified purposes. Records are maintained of important construction contracts, and abstracts are furnished as desired for cost trend studies. Schedules of land changes are furnished for correcting chief engineer's maps. Joint facility information is furnished general manager, auditor and many others.

Records maintained in the system valuation office enable that office readily to furnish a statement showing by accounts the I. C. C. reproduction cost new, as reported in the I. C. C. Engineering and Land Reports as of valuation date, plus net additions and betterments to any date desired, for the system as a whole, or for property located in any of the states traversed by the Santa Fe. When a detailed reporting is required, such as under the ad valorem form of taxation in California, the required information is prepared from map and facility records on file in the district valuation offices.

Reporting to the State Board of Equalization under the ad valorem form of taxation requires the preparation of land identification maps for each county showing all land in which the Santa Fe has ownership or which is wholly used by them, each parcel outlined in red and assigned a parcel number; and the preparation of tangible property lists for each county, segregating the property to code areas. A code area is the designation given to any portion of the county that is subject to the same combination of tax rates, and are assigned code numbers by the State Board of Equalization; and the preparation of summary statements showing the cost by accounts of the property in the state as a whole, and the cost per mile of road and track accounts for the various classes of track, which summary statements are used by the State Board of Equalization in placing an assessed value on the property located in each county.

Effective January 1, 1942, the I. C. C. instructed all Class I railways to establish depreciation accounting as a basis for current charges to operating expenses for the loss on roadway property furnishing transportation service. That order necessitated a determination of the original cost (effective date of the order), for each class of property having a different service life expectancy, and the determination of the rate at which each class of property would become obsolete or unserviceable. The system of records kept by the valuation forces made it possible to develop, with a minimum of expense, the information needed for compliance with the depreciation order. The records enable the Santa Fe to keep depreciation schedules on a current basis and to make future adjustments in the rates of depreciation in line with changing conditions.

The valuation department prepared schedules of property and costs of facilities involved where Santa Fe lands, buildings or tracks are rented to industries or to other railways. The rent charges must be compensatory. Accurate knowledge of the property involved, its cost, condition and value for the purpose intended, must be available. The valuation engineer, with authoritative records and necessary experience, determines those facts. Similar situations arise when the Santa Fe desires to buy property from another railway or from individuals; or the Santa Fe has purchased or is purchasing properties from other railways. That applies also to sales of land or facilities to others.

Whenever the Santa Fe desires to merge some of its separately owned properties under the ownership of another company, it must obtain the approval of the I. C. C. The application for such permit must be accompanied by considerable information, including schedules of the property involved and its original cost to date as established by the bureau of accounts of the I. C. C. Similar procedures are necessary to obtain permission to abandon a section of the Santa Fe for which there is no further public need.

Valuation records usually form the basis on which valuation engineers reach satisfactory agreements in connection with joint facility arrangements or trackage agreements between the Santa Fe and other railways. The making of such agreements, or their renewal, regularly require schedules of the property involved, its cost, physical condition and present value.

Railway accounting for many years has been rather closely supervised by the I. C. C. In the perpetuation of investment in road and equipment, all changes involving additions, improvements, and retirements are reflected in the investment in road and equipment accounts. In connection with retirements, the cost of property abandoned or replaced in former days was often not known. Before Federal valuation, such retirements in many instances had to be estimated, requiring in some cases field investigations or inventories, and estimates of original costs that were expensive to make, drawn out and often inaccurate. All retirements are now determined from valuation records for both accounting and valuation purposes—more readily than under the old system prior to valuation.

World War II created extensive work in negotiating settlements with the United States government for Santa Fe properties taken under the War Emergency Act for the construction and expansion of shipyards, housing projects, ordnance depots, army camps, naval bases and training fields. Much of that activity was handled by the Santa Fe's engineering department. The grand division valuation engineers furnished the cost and estimated value of the property involved and met with the government valuation representatives for the purpose of reaching an agreement on the value of property taken.

Details of the work of the grand division valuation engineers include the review of the accounting involved in several thousand engineering estimates each year for work on improvement programs for annual budgets. This review is made jointly with other forces in the engineering department who make a check of the engineering features in these estimates. Not only must the structural features of the proposed work be on a sound engineering basis, but the division of the costs between operating expenses and capital costs must be estimated in accordance with the accounting rules of the Interstate Commerce Commission.

When the work proposed by these estimates is done and the charges are recorded in the accounts, completion reports must be prepared for each and every project. The audit office furnishes a record of the costs charged to the work and a copy of all the accounting documents to the valuation engineer. The foremen on the work prepare reports of the materials and labor used and the field engineers prepare field close-out notes showing the structures or facilities constructed or retired on the projects. The field notes are also used by chief engineers to correct maps and other engineering records.

These reports and notes go to the valuation engineers to be checked against each other and compared with the accounting documents. With the data thus accumulated the valuation engineer's staff prepares the completion reports. Any discrepancies in the accounting performed, or inconsistencies between the materials used or the labor performed and the costs charged to the work, have to be reconciled and adjusted. On the completion reports the valuation engineers list the units to be reported as required by Valuation Order No. 3 and the costs applicable thereto, for work charged to investment. For important buildings the cubage (cubical content) must be given, and for signal and telegraph work the installations are reported in terms of adjustment units, a term peculiar to that kind of work, the determination of which requires cooperation with the signal and communications departments. For land the reports must show grantor, grantee, deed reference, area, map and parcel reference and the cost. For retirements of property, except for retirements made in betterment work, the valuation engineers furnish details of units and costs for the preliminary budget estimates and also for the completion reports.

Some valuation tasks require many months of detailed investigation and computation with a sizable force of engineers and computers involved. Applications for certicates of public convenience and necessity on proposed line extensions require field surveys and the preparation of costs, values, historical facts and other data, which the valuation department assists in preparing. Cost schedules, construction dates and classifications of road property for depreciation purposes are necessary when subsidiary lines are merged with the Santa Fe.

The construction of joint terminal facilities, depots, yards, tracks and other necessary facilities, embodies a great deal of detailed investigation and preparation. When the Santa Fe participates in such endeavors, the valuation department assists in the very considerable task of ascertaining the Santa Fe's overall position in the matter in relation to costs, land values, condemnations and other factors.

Valuation department records embrace countless historical facts. Almost daily someone desires to know when a particular Santa Fe development took place, why it took place and details in relation thereto. That same request may concern the date a bridge was constructed, a track, a branch line, or the development of a terminal. Questions frequently arise as to why the Santa Fe built through a certain community and why it built near and not through other communities. Those questions are logical and the valuation department usually can supply definite answers.

Santa Fe history is replete with interesting facts and Santa Fe executives and departmental heads, also the press and public, often desire to know when certain incidents took place and the details behind them. The broad operations of the Santa Fe and its near eighty years of operation, embracing as it does the development of much of the Southwest and the growth of national commerce on its present grand scale, involves many details not commonly known.

Many of the valuation department's assembled historical facts are in bound volumes, known as "splinters" of Santa Fe history. There is scarcely any Santa Fe development or construction of any scope, the details and facts concerning which are not included in the valuation department historical archives. If it were not for the interest displayed in Santa Fe history by members of the valuation department, much of that valuable information would have gone unrecorded.

The system valuation engineer participates in conferences of the bureau of valuation, Interstate Commerce Commission, at Washington. Those conferences, held several times yearly, concern valuation proceedings, development of prices, valuation trends, depreciation rates and bases, and related matters. The system valuation engineer is a member of committees within the Association of American Railroads.

These committees deal with valuation matters other than prices or valuation trends. The western group of railroads has an organization of cost data subcommittees serving under the direction of a general engineering committee. The system valuation engineer is a member of the engineering committee and serves on several of the subcommittees. These subcommittees assemble and analyze cost data and reach conclusions as to changes in prices or trends in costs of railroad construction work. They have annual conferences with the bureau of valuation, Interstate Commerce Committee, at Washington, resulting in joint committee reports which are distributed to all railroads for general reference.

Chicago, Illinois

October 15, 1947

Santa Fe