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The New Chicago Terminal Station of the Chicago & Northwestern Ry.

One of the latest examples of large passenger stations in this country is the new Chicago terminal station of the Chicago & Northwestern Ry., which was opened to traffic on June 3, 1911. This railway operates at its terminal a larger passenger traffic than any other railway entering Chicago, and has about the largest number of passenger trains handled at any of the terminal stations in that city. The present number of its inbound and outbound trains is about 300 daily, and about 60% of the trains are in suburban service. It may be noted, also, that this is the only railway having a terminal station for its own exclusive use; the other five teminals in Chicago are used by three or more railways each. The location of the several terminal stations is shown in Fig. 2.

The old terminal station of this road at Kinzie and Wells Sts. has long been outgrown by the traffic, although it has been enlarged at different times by the purchase of additional land for tracks and platforms. Its accommodations for passengers also were limited and not in accordance with modern requirements. Further extension was prevented, however, by a public street along one side and the river on the other side of the property. In addition to this, the station had the objectionable feature of requiring two drawbridge crossings for passengers. Close to the end of the station yard the railway crossed the north branch of the Chicago River by a bascule bridge,* while a great majority of the passengers had to cross the main stem of the river in going to and from the stations.

The question of a new station and a new site was under consideration for some years, and in 1905 it was decided to build the station which has just been completed. The original project was outlined in our issue of Oct. 18, 1906. This new station is estimated to be capable of handling 1,200 regular trains daily, so that it makes ample provision for future growth of the traffic. The view herewith shows the Madison St. front and Canal St. side of the station.

*Engineering News, Nov. 24, 1910.

Table I. gives a comparison of this station with some other large stations of the same class, and it will be noted that it ranks sixth according to the number of station tracks (ranking with the Philadelphia terminal of the Pennsylvania R. R.), and seventh according to the number of regular trains daily. The last column of this table is of interest in showing the approximate number of daily movements in several large stations. The handling of empty trains into and out of the station practically doubles the number of regular train movements, and, in addition, there are various light engine and switching movements which increase the total very considerably.

In regard to the location of railway passenger terminals, it has been claimed that for very large cities it is desirable to locate the stations in the outskirts (where land is less expensive), leaving the distribution of passengers to local transportation systems. This idea does not appear to be in favor among the railway officers who have the power of deciding the location, and who have evidently a strong belief in the strategic and commercial advantages of a conspicuous and centrally located terminal station. Such a location is of special advantage in this case, owing to the heavy suburban traffic, since it enables a large proportion of the suburban passengers to walk to and from the station and their places of business.

THE NEW CHICAGO PASSENGER TERMINAL STATION OF THE CHICAGO & NORTHWESTERN RY. (MADISON ST. FRONT).

Edward C. Carter, M. Am. Soc. C. E., Chief Engineer. W. C. Armstrong, M. Am. Soc. C. E., Terminal Engineer. Frost & Granger, Architects.

The new station is located one block west of the river, so that it has no drawbridge to interfere with train movements. The main front is on the north side of Madison St., between Canal and Clinton Sts., and the station extends four blocks north to Milwaukee Ave., covering an area of about eight acres. The train floor is elevated above the street level, and is carried across intersecting streets by steel bridges. There are two four-track elevated approaches, one for the Galena Division (from the west) and one for the Wisconsin Division (from the north). These converge upon a six-track approach, from which the tracks diverge to the station yard and trainshed.

The main building is 320 × 218 ft., while the trainshed and station yard occupy a space 320 × 1,072 ft. The right-of-way acquired for the station and approaches aggregated 37 acres, of which 20 acres were covered with buildings; there were 455 buildings wrecked or moved, 66 of these being four stories or more in height. The station and approaches necessitated the bridging of 40 streets and 13 alleys.

At the point where the station crosses Washington St. is the inclined approach to the Washington St. tunnel of the street railway system, and this necessitated special arrangements of the columns and foundations. The carrying of the elevated approach across Lake St. necessitated the raising of the Chicago & Oak Park Elevated Ry., and the substitution of a truss span (across the approach) for the shorter plate-girder spans of the elevated structure at this point. The work for the tunnel and for the alterations to the elevated railway were described in our issues of July 21, 1910, and Dec. 9, 1909, respectively.

Some idea of the extent of the work may be gathered from Table II., which includes both the station and the approaches.

The entire work of design and construction was under the supervision of Mr. Edward C. Carter, M. Am. Soc. C. E., Chief Engineer of the Chicago & Northwestern Ry.; the execution of the work was under the direct charge of Mr. W. C. Armstrong, M. Am. Soc. C. E., Terminal Engineer. The signal and interlocking plant was designed by Mr. J. A. Peabody, Signal Engineer. The architects for the building were Frost & Granger, and E. C. & R. M. Shankland were the structural engineers for the architects. Pierce Richardson & Neiler were the mechanical and

TABLE II.—SUMMARY OF WORK ON THE CHICAGO TERMINAL STATION, CHICAGO & NORTHWESTERN RY.

Area of right of way	37 acres.
Excavation	250,000 cu. yds.
Piles driven; No. 43,000	1,530,000 lin. ft.
Concrete	265,000 cu. yds.
Structural steel in station and in street bridges	37,000 tons.
No. of foundation piers	316
Paving	42,800 sq. yds.
Concrete sidewalk	25,000 sq. yds.
Curbing	22,000 lin. ft.
Waterproofing	74,000 sq. yds.
Length of tracks: Terminal sect.	34,500 ft.
West approach	26,700 ft.
North approach	33,500 ft.
Total (18 miles)	94,500 ft.
Cost: Real estate & legal proceedings	$11,560,000
Station building and trainshed	6,380,000
Power station and equipment	810,000
Elevated approaches	5,000,000
Total	23,750,000
Work commenced. Clearing site	Nov., 1906
Construction of approaches	Sept., 1908
Construction of station	Nov., 1908
Erecting steel	Feb., 1909
Station opened for traffic	June 3, 1911

electrical engineers. The principal contractors were as follows: foundations, masonry and station building, the Geo. A. Fuller Co.; steel work, American Bridge Co.; erection of steel work of trainshed and bridges, Strobel Steel Construction Co.; foundations and concrete work of terminal section, Geo. W. Jackson; concrete work of north and west approaches, Bates & Rogers Construction Co. and J. J. O'Heron Co., respectively. The filling of the solid portion of the approaches and the laying of all track work was done by the railway company's engineering department.

Foundations.

The character of the soil at the station site is that which occurs mainly in the business portion of Chicago. The top layer of filled material was underlaid by soft muck and then by a bed of blue clay; the clay is mainly stiff, but soft in places, and has occasional pockets of quicksand. Hardpan occurs at about 85 ft., and solid rock at 115 to 120 ft. below the street level. The whole area from Madison St. to Milwaukee Ave. was first excavated to a depth of about 8 ft. below the street level, the excavation being made deeper where required for basements, pump pits, elevator shafts, etc.

The main foundations consist of concrete piers (or so-called caissons) built in open wells or shafts in the manner now customary for large buildings in Chicago. For the lighter loads of the interior columns carrying the trainshed, pile clusters are used under each footing. These piles are about 50 ft. long and spaced 2 ft. c. to c., and carry an average load of 18 tons per pile. The footings have a base area of 10 × 10 ft. for a single pedestal 4 × 4 ft., or 10½ × 22½ ft. for a footing carrying two pedestals. The reinforced concrete retaining walls for the deeper part of the basement of the building are about 22 ft. high; they are 2 ft. wide on top, with the back sloped to give a width of 12 ft. at the street level, while at the base the toe is extended to give a width of 17 ft. over the supporting piles. These walls are of gravel concrete 1:2:5.

The concrete foundation piers mentioned above are 216 in number with a diameter of 4 to 8 ft.; of these, 172 are under the station building, 36 under the retaining walls of the Washington St. tunnel approach, 4 under the bridge carrying the station approach over Lake St., and 4 under the smokestack of the power-house. Those under the station are spaced 32 ft. apart longitudinally and from 16 to 18 ft. transversely. More than half of the piers are founded on hardpan at a depth of about 85 ft. below the street level, but it was necessary to carry 97 of the piers to bed rock; the maximum depth of these latter piers was 120 ft. 8 ins. Four of these deep piers are under the smokestack, the others are under different parts of the station. In some of the shafts quicksand was encountered, and it was necessary to employ the pneumatic system.

The concrete for the piers, retaining walls and footings was prepared by a mixing plant installed in the excavated area, below the street level. The storage bins for material were beneath a platform at this level, so that wagons could dump stone, gravel and sand directly into them. The materials were discharged through bottom hoppers into a belt conveyor which delivered them to a bucket conveyor, by which they were raised to elevated hoppers. From these the materials were fed by gravity to measuring boxes, and then discharged directly into a drum mixer of 1 yd. capacity. The mixer delivered the concrete into steel side-dump cars running on portable tracks.

Station Building.

The station building includes not only the headhouse proper, but also the space beneath the trainshed, this latter affording convenient accommodation for many of the station facilities. This is shown by the plan, Fig. 3. The space on the first block (from Madison to Washington Sts.) includes the first floor of the headhouse and the inbound baggage room, baggage wagon driveway, and carriage entrance. In the next block (to Randolph St.) are the U. S. post-office substation, immigrants rooms, and a cab stand. Here also is a broad concourse specially for the use of suburban passengers and having stair-

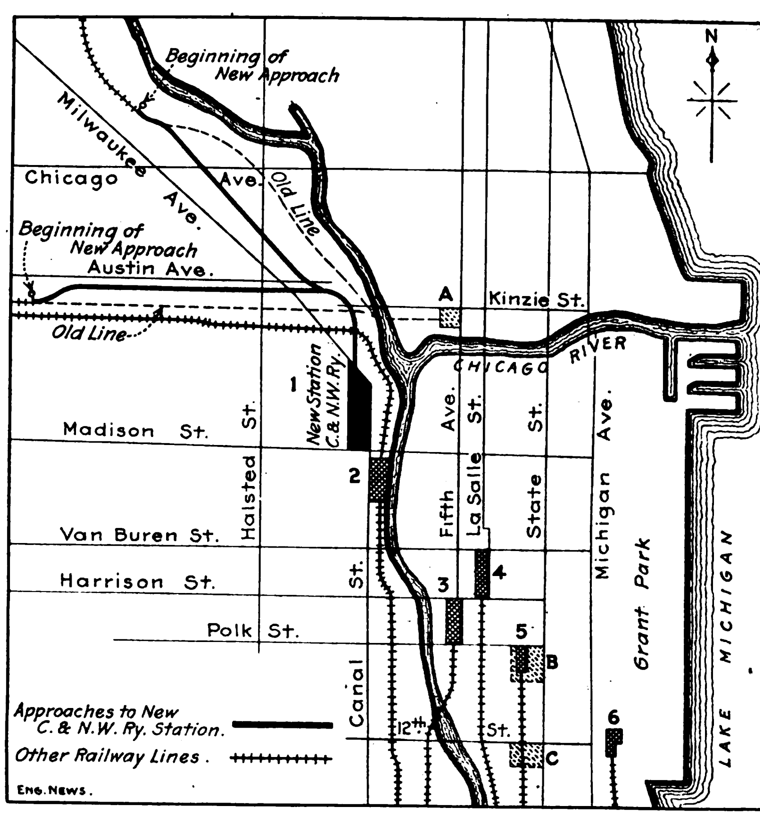


FIG. 2. MAP SHOWING THE RELATIVE POSITIONS OF RAILWAY TERMINAL STATIONS IN CHICAGO.

A.—Old Kinzie St. Station; C. & N. W. Ry. (Abandoned.)
B and C.—Proposed sites for new Dearborn Station.
1. New Station; Chicago & Northwestern Ry. (Madison St.)
2. Union Station (Adams and Canal Sts.).
3. Grand Central Station (Harrison St.)
4. La Salle Station (Van Buren St.).
5. Dearborn Station (Polk and Dearborn Sts.).
6. Park Row Station.

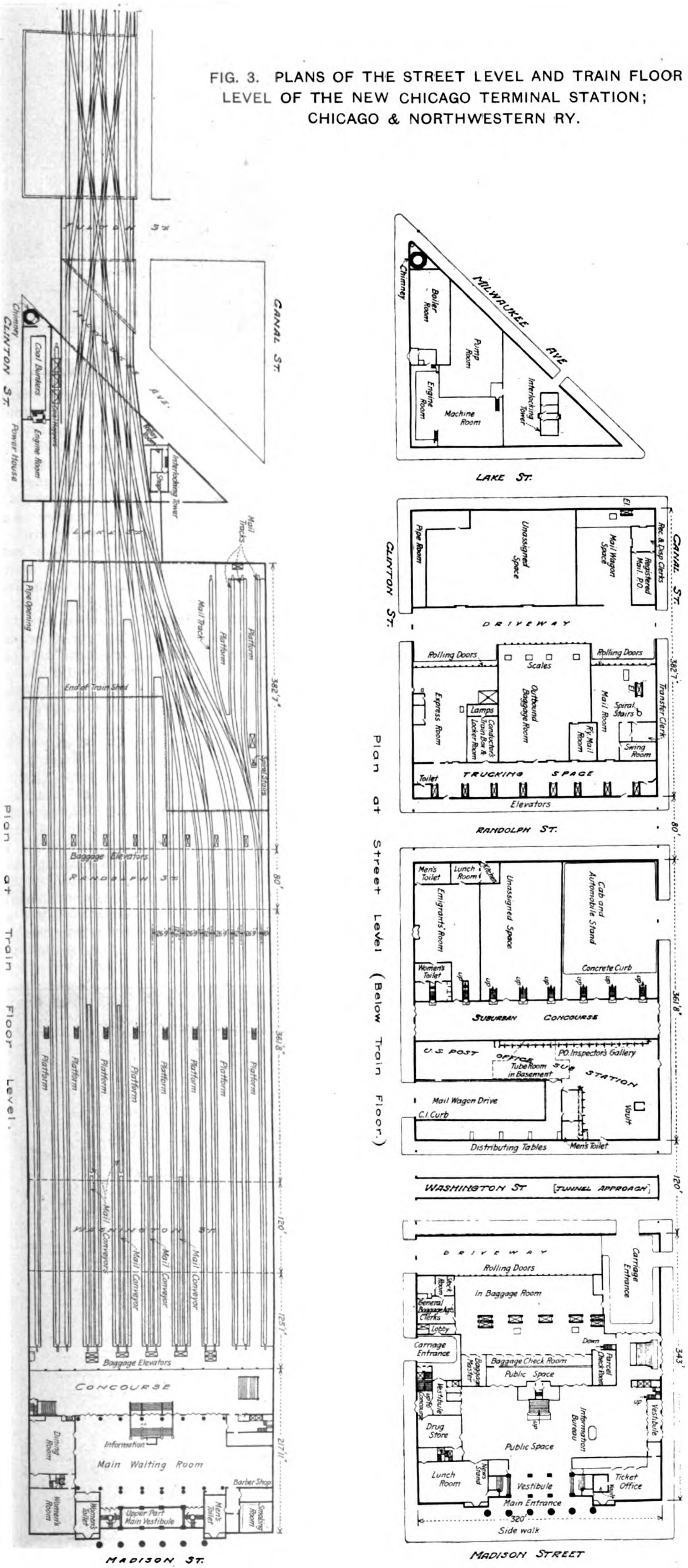
ways from the train platforms. Thus incoming passengers can go from the train platforms to the street without passing through the main part of the station. The arrangements are so planned, however, that the concourse may be adapted for use by both outgoing and incoming suburban passengers, if this should be desirable. This is likely to be the case, a request to this effect having been made already on behalf of suburban passengers coming to the station from the north end, and who have to walk all the way to the main building and then back through the station to their trains.

TABLE I.—PARTICULARS OF SOME LARGE RAILWAY STATIONS.

Stations: City.	Railway or Terminal Co.	Class.	No. of tracks in train shed.	Platforms: No.	Length. ft.	Width of station or train shed. ft.	Daily number: Schedule trains (in & out).	Total movements (Estim.)*
St. Louis	Term. R. R. Assoc	Union	32	17 (12 ft.)	810	606	322	2,010
Washington	Wash. Term. Co	Union	31	18	900 to 1,000	760[1]	244	2,500
Boston (So. Sta.)	Bos. Ter. Co	Union	28	14 pass. 8 bagg.	610 to 950	570	786	3,500[2]
Boston (No. Sta.)	B. & Me. Ry		23	13	728	459	607	2,950
New York	Penn. R. R		21	11 pass. 4 bagg.	750 to 1,130	509	392[3]	....
Chicago	C. & N. W. Ry		16	8	740 to 840	320	300	....
Philadelphia	Pa. R. R. (Bd. St.)		16	8	680 to 1,060	306	574	3,400
Kansas City	K. C. Term. Ry	Union	pres. 16	8	1,400	390	313 (est.)	....
			fut. 24	12	1.400	612	...	....
Cincinnati	C. Un. Dep. & Term. Co	Proposed union	16 (equiv. to 32[4])	8 (21 ft.)	1,400 to 1,900	355	276 (est.)	....
Hoboken	D., L. & W. Ry		14	8 (20 ft.)	700[5]	335	263	....
Jersey City	Penn. R. R		12	6 pass. 2 bagg.	790	260	334	813[6]
Chicago (La Salle Sta.)	C., R. I. & P. Ry	Union	11	6	578	207	...	....
Chicago (Union Sta.)	Penn. Lines[7]	Union	3 thro. 6 stab.	4 pass. 2 mail	500 to 1,500	66 middle 132 ends	270	1,400
New York; Grand Central Station New York Central Ry.)	upper floor		42	16	16,415 total	820	422	694
	lower floor		22	17	14,380 total	578	57	117
	total		64	33	30,795 total	...	479	811

*Total number of movements includes schedule and empty trains, light locomotives and switching movements.
[1]Washington. No trainshed; platform shelters 355 ft. long.
[2]Boston (South Station). Regular and empty trains number 1,450 movements; switching movements, etc., bring the total to 3,500 or 4,000 movements.
[3]New York (Pennsylvania R. R.). The empty trains bring the train movements to 681.
[4]Cincinnati. This proposed union station would be operated from each end (like the Union Station at Chicago), so that the 16 tracks would be equivalent to 32 station or train tracks.
[5]Hoboken. The platforms are 700 ft. long, with 600 ft. covered by a trainshed of the Bush type.
[6]Jersey City. Including empty trains the number of train is 668. Before the New York station was opened the total number of movements was 813 per day.
[7]Chicago (Union Station). This is a double-end station, with no through trains. Therefore, two trains (of different roads) can occupy each through track simultaneously, pulling out in opposite directions.

FIG. 3. PLANS OF THE STREET LEVEL AND TRAIN FLOOR LEVEL OF THE NEW CHICAGO TERMINAL STATION; CHICAGO & NORTHWESTERN RY.



In the third block (to Lake St.) are the outbound baggage room, driveway for baggage wagons, express room, mail room, etc.; the mail room has elevators serving the platforms of short stub tracks for mail cars. The fourth block (to Milwaukee Ave.) is triangular in shape; this contains the power-house, and also the lower floor of the main signal tower. These accommodations, it will be understood, are at the street level.

We return now to the main building or headhouse, shown in Fig. 2. This is a four-story granite structure 320 × 218 ft., and is devoted entirely to accommodation for passengers and for the officers required in the station service and the handling of trains. No attempt was made to provide general offices for the railway company, as the company has its own 14-story office building for this purpose. The station building has a frontage of 320 ft. on Madison St., and the first floor has a depth of about 343 ft.; on the upper floors, however, the depth is only a little over 200 ft.

The architectural design is simple, and is in the style of the Italian renaissance. The feature of the main front on Madison St. is a portico extending the height of three stories, and having its street front formed by a row of six granite columns 7 ft. diameter at the base and 61 ft. high. Flanking the top of the portico are two small turrets or cupolas, each having clock faces 12 ft. diameter. Three lofty arched openings give access to a vaulted vestibule 132 × 22 ft., with a height of 40 ft. On the Canal St. and Clinton St. sides are less elaborate entrance vestibules, and at these entrances there are canopies extending over the sidewalk, for the protection of passengers going to and from cabs or omnibuses in bad weather. There is also, however, a carriage space within the station. The three vestibules open into a large open space, and all have broad stairways leading either to the main waiting room or to the concourse between this room and the trainshed. Elevators also are provided. The lighting and ventilating equipment is very complete, and the lighting of the waiting rooms includes indirect lighting (by concealed lights along the cornice) in addition to the usual clusters of exposed lights.

Around the large open space on the first floor are arranged the ticket office, parcels room, telegraph offices, lunch room, etc. This open space or entrance hall is shown in Fig. 4, with the doors to the Madison St. vestibule in the right and the main stairway to the concourse at the left. The photograph gives an appearance of gloominess, but as a matter of fact the hall is very light, and the coloring (green and cream color tile) is much lighter and brighter than might be supposed from the view. At the north end are the baggage checking counter and the inbound baggage room, with elevators to the train platforms. As noted already, there are two separate baggage rooms. The one for inbound baggage is at the south end, convenient to the head of incoming trains; the one for outbound baggage is near the north end, conveniently located to serve the head of outgoing trains. In this way the amount of trucking along the platforms is reduced considerably. The rooms are connected by a pneumatic conveyor system, having oval pipes 3 × 6 ins. for the transfer of baggage checks, etc., all business with passengers being transacted at the counter of the inbound baggage room in the main part of the station building.

On the second floor of the station (20 ft. above the street level) are the main waiting room, women's rooms, smoking room, dining room and toilet rooms. The waiting room is about 200 × 120 ft., with a height of 85 ft.; it has a barrel-vaulted roof extending above the main roof of the building and having clerestory windows. This room is shown in Fig. 5; at the left are the main stairway and the doors opening upon the concourse. The third and fourth floors are at the sides of the building only, the waiting room occupying the entire central space. On the third floor are the offices of the division engineers, superintendents, train dispatchers, etc.; also the barbers' shop and bath and toilet rooms.

FIG. 4. MAIN HALL OF CHICAGO TERMINAL STATION, C. & N. W. RY.

Here also is the matron's room and a rest room for women who may be sick or may have to wait for some considerable time, and can thus have more quiet than is afforded by the accommodations on the main floor. On the fourth floor are the telephone exchange and offices for the electrical engineers, sleeping car officials, etc., also rooms for the use of the train conductors. In the basement are the kitchen, baggage store room, heating and ventilating plant, and various rooms for the employees.

The concourse (or space between the waiting room and trainshed) is 60 ft. wide and extends the full width of the building. It is unique in being formed as an enclosed space, a glazed partition shutting it off entirely from the trainshed. In most stations the concourse is simply a broad platform at the end of the train platforms, from which it is separated only by an iron fence. The enclosed arrangement will give greater comfort and convenience, and in winter it will serve to prevent drafts in the concourse and waiting room.

The building is of steel frame construction with brick walls and floors of hollow tile construction; the floor of the waiting room, however, is carried by vaulted tile arches which form the ceiling of the open space or entrance hall on the first floor. The roof is of reinforced concrete 3½ ins. thick, covered with 1-in. tile and a waterproof roofing composition. The roof of the waiting room is carried by arched trusses of 90 ft. span and 31 ft. rise, giving a clear height of 84 ft. above the floor.

Trainshed.

The trainshed is 320 ft. wide, with a length of 940 ft. from the concourse, except that on the east side it is about 200 ft. shorter (for seven tracks) in order to give room for the leads from the approach to the station tracks on this side. It is of the Bush type (patented by Mr. Lincoln Bush, M. Am. Soc. C. E.), having low short spans with a longitudinal opening above each track to carry off the smoke and gases from the locomotives. Fig. 6 is an interior view from the concourse, and shows also the baggage elevators and the heavy steel bumping posts at the ends of the tracks. Fig. 7 is a cross section of the trainshed and the structure which supports it (forming the first story of the building); Fig. 8 gives the details of construction.

There is a single row of columns in the center of each platform, the columns being spaced about 38 ft. 9 ins. transversely (c. to c. of platforms) and 25½ ft. longitudinally. These carry the plate-girder arched ribs of the roof. At each side is a half-arch span from the platform columns to columns in the side walls. The springing line of the ribs is 11 ft. above the rails, and the rise of the arch is about 5 ft. 11 ins., giving a total height at the center of 16 ft. 11 ins. above the rail level. Each column consists of a pair of 12-in. channels, with the flanges facing and connected by lacing bars. The columns are connected longitudinally by struts composed of two 10-in. channels, with a ½-in. bottom plate 18 ins. wide. Between each pair of arch ribs is a framing consisting of two I-beam rafters (bent to conform to the curve of the roof) and longitudinal purlins of 6-in. bulb angles. There are also lattice girder longitudinal struts between the ribs, so spaced as to form (with the concrete in which they are encased) the sides of the longitudinal openings over each track. In each span there are these longitudinal openings, wire-glass skylights 5 ft. wide over the platforms, and a central row of ventilators.

The longitudinal openings above mentioned are 36 ins. wide, and the concrete slabs forming their sides are 57 ins. deep. These slabs project far enough above the roof to exclude drainage water, and far enough below it to prevent driving rain or snow from reaching the platforms. Holes in the slabs prevent the pocketing of gases behind them. The roof framing is not encased in concrete, except in regard to the lattice struts of the openings, and the portions of the ribs which extend across these openings. A cast-iron shoe under this part of each rib protects the concrete covering from injury, and is about 5 ins. clear above the tops of the tallest smokestacks. The steel framing and the columns are painted a light gray color to harmonize with the concrete of the roof and smoke ducts.

Upon the steel roof framing is a 2½-in. concrete roof slab, reinforced with wire mesh near the inner face, and covered with composition roofing. The roof drainage is led to gutters in the valleys, and thence by downspouts at alternate columns to the sewer connections. A snow load of 20 lbs. per sq. ft. is assumed for the roof loading. The trainshed roof is not visible from the street, being screened by carrying the side walls above it, or to a height of nearly 50 ft. from the street. Along the inner side of one wall (above the roof) is a gallery for pipes and electric conduits. These walls are of gray brick with stone coping and string course. As there are no windows, they present a rather large unbroken area, relieved only by a little paneling. The trainshed is lighted by both arc and incandescent lamps.

The trainshed floor is carried by a steel framing with columns resting on concrete pedestals and footings with pile clusters, as described already under the head of Foundations (and shown in Fig. 7). In most cases, each footing has two pedestals and supports two columns. For each track (except two) there is a single row of columns, spaced 25 ft. longitudinally. The columns have bracketed tops wide enough to carry two lines of plate girder stringers 5 ft. apart and they support transverse plate girders which extend the full width of the building and carry the stringers for the tracks, platforms and roof columns. These girders have double webs, embracing the columns, thus making a very rigid floor system. At the east side of the line of columns on the south curb of Washington St. it was necessary to provide room for a driveway under the first pair of tracks, so that these could not be supported directly by columns.

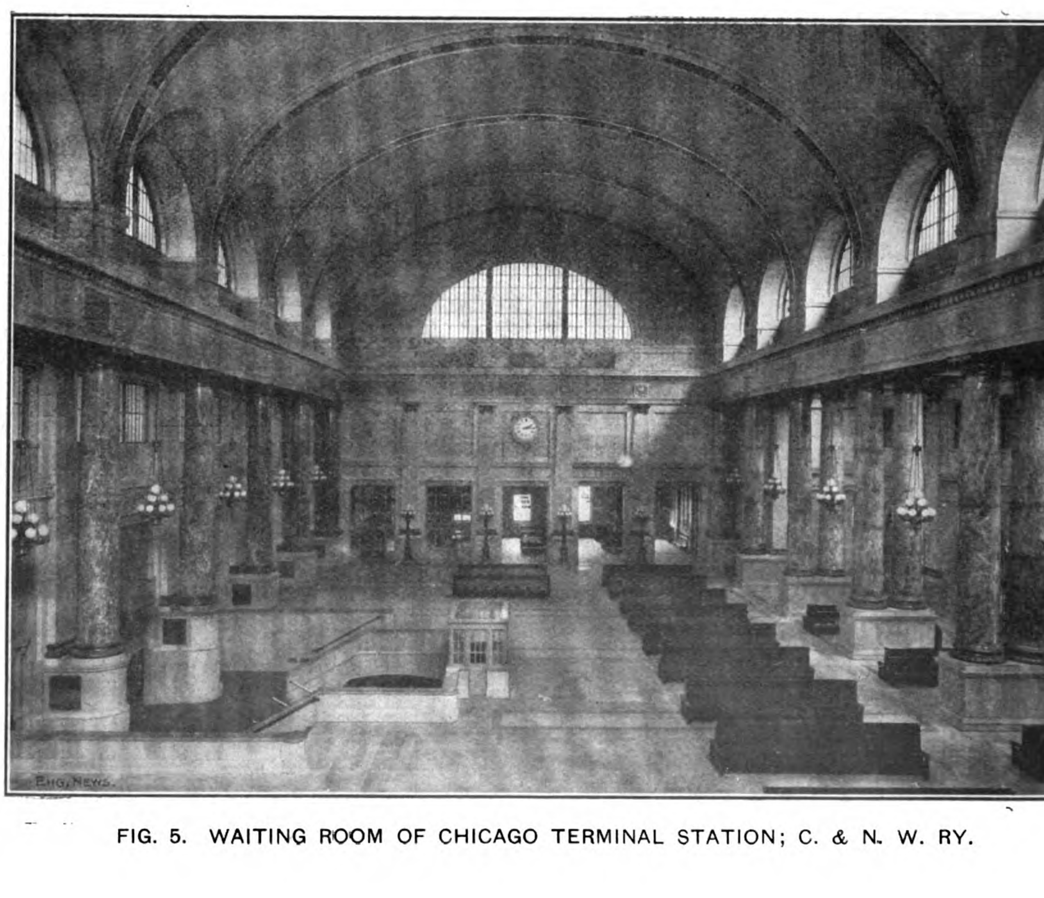


FIG. 5. WAITING ROOM OF CHICAGO TERMINAL STATION; C. & N. W. RY.

Here the columns are set 33 ft. apart, and the track stringers are carried entirely by the transverse plate girders, as shown in the cross section (Fig. 7).

Platforms and Trainshed Floor.

The trainshed has a solid floor of concrete resting upon shelf angles on the girders and track stringers. This is covered with waterproofing and provided with ample drainage outlets so that the entire surface can be cleaned by flushing. The concrete for the track floor is about 16 ins. thick, giving sufficient mass to absorb vibration; for the platforms it is about 6 ins. thick. In each case there is a 2-in. surface of asphalt mastic upon the concrete, with a layer of burlap in the asphalt. This forms the waterproofing and wearing surface. The platforms are 16 ft. 9 ins. wide, with a slight fall from the center to each side, the edges being 8 ins. above the level of the rail heads.

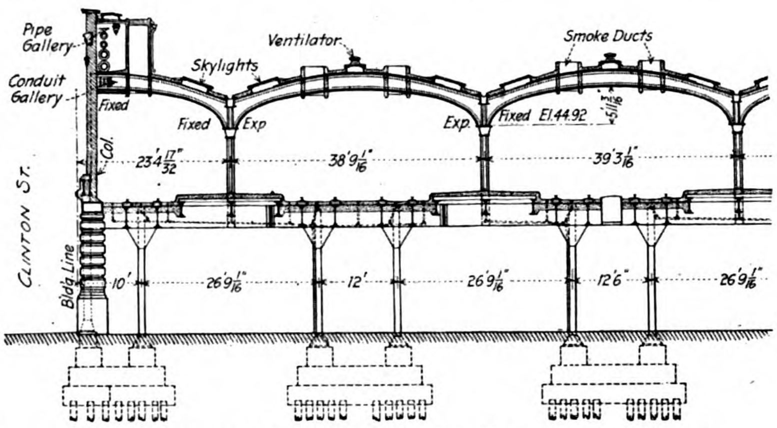


FIG. 6. PART CROSS SECTION OF TRAINSHED AND ITS SUBSTRUCTURE.

The application of the waterproofing was done under the supervision of the engineering department of the Standard Asphalt & Rubber Co. For the floor work, the specifications provided that on the clean and dry surface of the concrete there should be applied by brushes an asphalt primer coat (thin enough to penetrate the concrete) to ensure the close adhesion of the main coating. When the primer coat was dry, the waterproofing was applied at about 450° F. and in this was laid open-mesh burlap in three layers, each well mopped with the hot asphalt. The three-ply waterproofing mat thus formed is anchored in a recess in the concrete side walls, and is secured to the wood track stringers with metal flashing strips. This waterproof seal construction along the stringers is designed to maintain a close connection at all temperatures and in spite of the vibration due to train movements. Upon this mat is a 1½-in. coat of mastic which is given a cement finish. For the platforms, a two-ply burlap and asphalt mat is used. The mastic surface was leveled to the required thickness by the use of wood spreaders and floats. The finished surface was sprinkled and rubbed with fine sharp sand, which was swept off while the material was still hot. The surface was then rubbed with Portland cement, sufficient pressure being applied to eliminate all voids and blow-holes and to give a dense and homogeneous finish to the surface.

Track Construction.

The track construction in the trainshed is of special and interesting design, and is shown in Fig. 9. The rails are of the 100-lb. Am. Soc. C. E. section, and are carried by longitudinals of Oregon fir, 7½ × 15½ ins., which are laid directly upon the top chords of the track stringers. Steel tie plates ½-in. thick and 8 × 8 ins. in size are spaced 2 ft. c. to c., or 15 to a 33-ft. rail length. At each plate the rail is fastened to the timber by two screw spikes. The rail joints are spliced with 26-in. bars of the Continuous type, ⅞-in. bolts being used, and each bar held by the heads of two screw spikes. At each track stringer, a trough is formed in the concrete floor to receive the longitudinal timber.

The timbers are attached to the stringer flanges by hook bolts about 3 ft. apart and the arrangement for setting these bolts and providing for their removal is similar to that designed by Mr. Armstrong for the Lake St. bridge carrying the elevated railway across the approach tracks, which was described in our issue of Dec. 9, 1909. Iron pockets are embedded in the top of the floor concrete, forming pockets which project beneath the stringer flanges. When the timber is in place and the nuts are screwed home, the pocket is filled with soft asphalt, and the same material is used also as a filler in the 1-in. hole for the ¾-in. bolts. When the waterproof floor is laid the space between the concrete and the timber is filled with asphalt, and the burlap is carried under the face of a light sheet iron angle let into the side of the timber. Soft asphalt is then filled in at the top, as shown.

Track Plan.

The two four-track lines approaching the terminal unite in a six-track approach to the station, and this in turn spreads out to 16 tracks in the trainshed. The tracks are arranged in pairs, alternating with the platforms, except that at each side there is a single track next to the wall. The spacing of the tracks is alternately 12 ft. and 26 ft. 9 ins., while the platforms are 38 ft. 9 ins. c. to c. At the northeast end are four short stub tracks for mail cars, and the platforms for these are served by four elevators connecting with the mail room below. On the northwest side there is a stub track at the power-house for cars delivering coal and removing ashes. All these stub tracks are reached by reverse movement from the station.

The longest station track is 1,235 ft., and will accommodate a train of 18 cars; the shortest is 780 ft., for 11 cars. The total length of station tracks is 14,330 ft., accommodating 200 cars. Two pair of diagonal tracks across the six-track approach, with double slip switches at all intersections provide connection for any one of the approach tracks with any one of the station tracks. These slips have No. 7 frogs, so as to give easy and safe passage. There are 82 switches, 4 lap switches, 39 double slip switches, and 6 track crossings. The station track plan is shown in Fig. 3, while Fig. 10 is a diagram plan (not to scale) of the track layout of the entire terminal with its approaches.

Signals and Interlocking.

All the block signals and interlocking are operated electrically, this including the control not only of the signals but also of the switches and movable-point frogs. The signals are of the three-position semaphore type, working in the upper right-hand quadrant; the signals governing high speed moves are mounted on signal bridges, while the low-speed signals are of the dwarf type. This latter type is used entirely for the terminal plant proper. Each dwarf signal has a large revolving white disk (instead of an arm); the disk has a red stripe representing a semaphore arm, and two holes for the lenses. This signal is more conspicuous than the ordinary small semaphore arm used for dwarf signals. For the high-speed signals there are 11 steel bridges (Fig. 10). The track circuit is operated from storage batteries, which are charged by means of motor-generator sets in the towers; current for this equipment is supplied from the power-house. The General Railway Signal Co. had the contract for all the signal and interlocking work.

There are five signal towers on the terminal system (see Fig. 10): (1) Lake St., at entrance to station; (2) Clinton St., at junction of north and west approaches; (3) Carpenter St., at entrance to Erie St. coach yard; (4) Division St., at connection of north approach with the Wisconsin Division; (5) Noble St., at connection of west approach with the Galena Division. The equipment of these towers is given in Table III. The switch levers have indicator lights to show when they

FIG. 7. INTERIOR OF TRAINSHED OF CHICAGO TERMINAL STATION; CHICAGO & NORTHWESTERN RY.

are unlocked, these lights being controlled by the detector circuits.

TABLE III.—LEVERS OF SIGNAL TOWERS ON THE NEW CHICAGO TERMINAL OF THE CHICAGO & NORTHWESTERN RY.

Levers.	Lake St.	Clinton St.	Carpenter St.	Division St.	Noble St.	Total
For signals	67	29	8	12	10	126
For dwarf signals	..	33	15	11	11	78
For switches ...	29	26	7	25	7	94
For double slip switches........	46	12	8	6	8	80
For movable point frogs	23	6	4	3	4	40
For derails	..	35	13	17	11	36
To govern traffic	6	14	6	6	4	76
Working levers..	171	155	61	88	55	530
Spare spaces.....	37	13	15	32	25	122

Two of the tracks on the north approach are signaled for operation in both directions. The traffic on these tracks is reversed at noon and midnight each day. This is done on account of the heavy suburban business, requiring a large number of empty coach trains going to the yard in the morning and being fed from the yard to the terminal station in the afternoon. In order that these may not have to cross through the inbound schedule trains at two places in the morning, the reversal of the traffic on these tracks was determined on as a very ready means of obviating this difficulty.

A system of using small electric lights as in telephone work is provided for rapid communication between the signalmen at the various towers. There is also a system provided for communication between train conductors on the platforms, the gatemen, the ticket inspectors and the tower director at the Lake St. signal tower. By this the towermen and gatemen are advised by the conductor when the train will be ready to leave; the gateman and conductor are advised by the tower director when the train will be handled; and the conductor and tower director are advised by the gateman when the gate has been closed and train may leave.

In the main tower at Lake St. and also in the second tower at Clinton St., there is provided a large illuminated diagram on which is indicated the position of each train in each part of the yard or on the station tracks. This is so constructed that the moving of the train on the tracks into or out of the depot or within the limits of these interlocking plants is shown, so that the tower director may know even in stormy weather or at night the exact location of each train at all times.

aggregate length of about 1,200 ft. This equipment was built by the Stevens-Adamson Mfg Co. The belts are 26 ins. wide, and are 30 ins. below the floor level; their running speed is 300 ft. per min., and this is attained in 10 secs. after starting the motor. Each belt runs in a steel trough 36 ins. wide, covered by watertight, roller-bearing cover plates, which are checkered castings ⅜-in. thick. These extend the whole length of the trough, and when closed they are locked automatically and form a service walk between the tracks. The cover can be opened at any desired point.

When a mail train arrives, the mail sorting room of the post-office (beneath the train floor) is notified by a gong signal, and an indicator shows which conveyor is to be operated. The conveyor cover is opened at a point convenient to the mail car, and the sacks are thrown directly upon the belt, which delivers them to chutes leading to the sorting tables. There are also two platform elevators which deliver mail sacks to chutes at the rear ends of the conveyors, and the sacks from the elevators are thus conveyed to the sorting room by the conveyors.

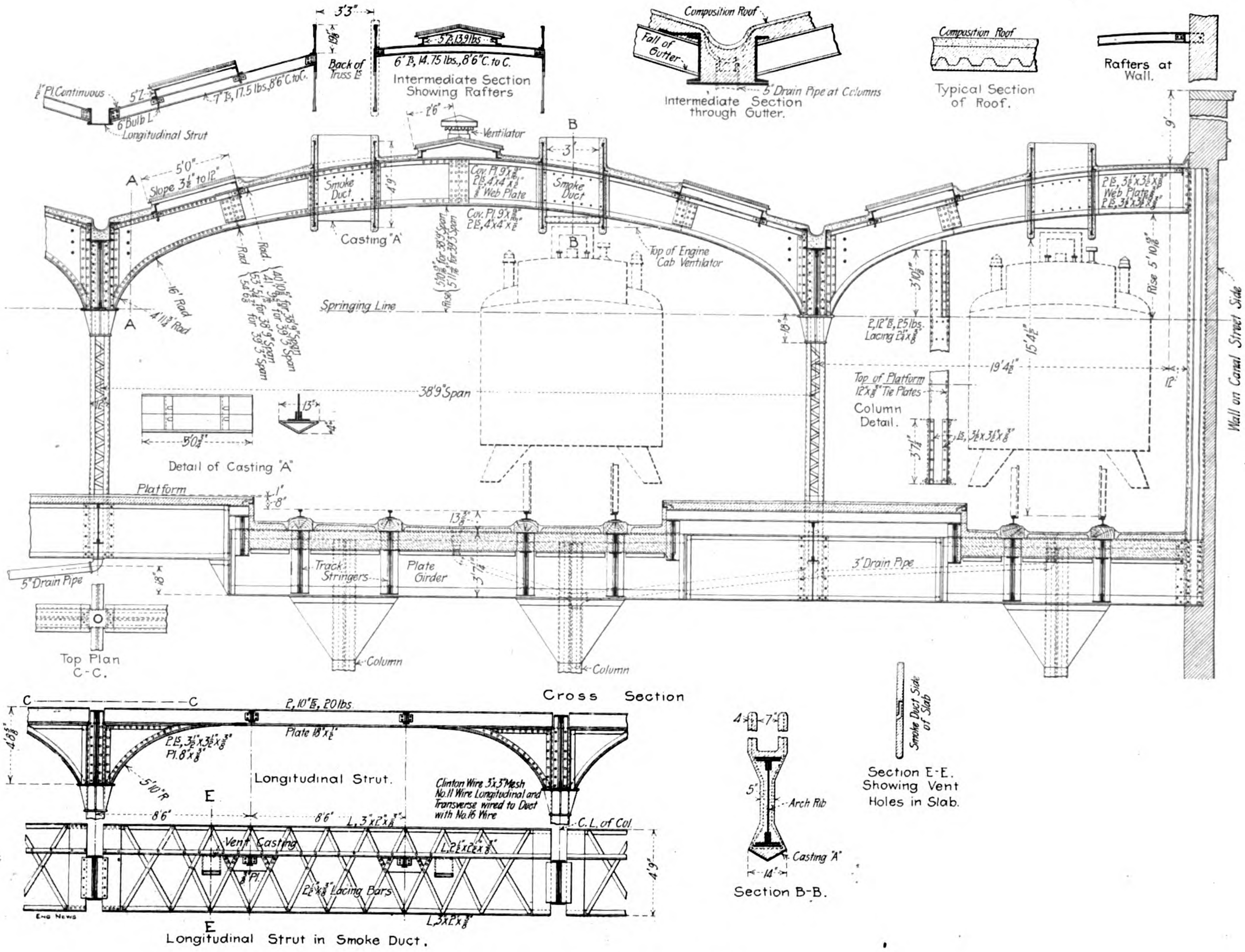


FIG. 8. DETAILS OF TRAINSHED.

A special feature of the equipment is a system of snow melting provided in the terminal station yard so as to save the necessity of having to load and haul away the snow that may collect.

Conveyors and Elevators.

A specially interesting feature of the equipment is that conveyors are provided for handling the mail from incoming main-line trains and delivering it to the sub-post-office located in the station, without interfering with the traffic on the passenger platforms. At four of the pairs of tracks, electrically operated belt conveyors are placed in the space between the tracks, and in two of these cases there are two conveyors (placed in line with one another). The conveyors are from 148 ft. to 225 ft. in length, with an

The elevator system includes 14 high-pressure hydraulic elevators and 10 electric elevators; of the hydraulic elevators, 7 are for baggage, 5 for passenger service and 2 for special service; of the electric elevators, 8 are for baggage, express and mail, and 2 for mail only. A pneumatic tube system connects the inbound and outbound baggage rooms, to provide for the transfer of tickets, baggage, checks, etc. This system has an elliptical tube 3 × 6 ins., with carriers 9 ins. long.

Power Plant.

The power-house is located conveniently in the triangular block at the north end of the station. At one side of it is a short stub track for cars delivering coal, the same cars taking ashes from an overhead bin. The cars discharge the coal into a track hopper of 400 tons capacity (and long enough for two cars to be unloaded at

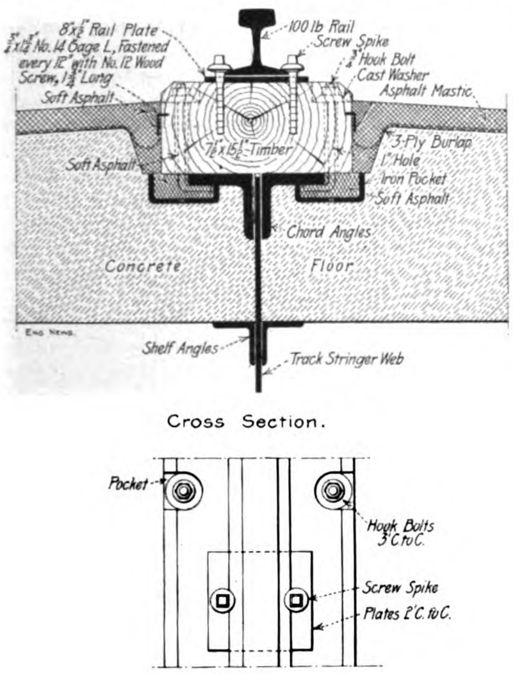


Fig. 9. Track and Floor Construction of Trainshed.

once); a conveyor then delivers the coal to a crusher, from which it is discharged upon a bucket elevating conveyor which serves an overhead coal bunker of 750 tons capacity. This conveyor plant is capable of handling 40 tons per hour. The coal conveyor also serves the ashpits, and delivers the ashes to an inclined conveyor discharging into a storage bin of 100 tons capacity. Under the sidewalk, and on a level with the boiler room floor is an auxiliary coal bunker of 300 tons capacity.

There are six water tube boilers of 500 HP. each, arranged in battery. They are built for 200 lbs. working pressure and are equipped with superheaters and traveling chain gates. An exhaust steam turbine driving a 500-KW. 230-volt D. C. generator is installed, space being left for a future unit of the same size. This turbine is connected to the main exhaust line and utilizes exhaust steam from the cross-compound, non-condensing engines. The heating system is also connected to this exhaust main, live steam being fed into the exhaust line through pressure reducing valves to make up whatever additional steam is required for heating or for the exhaust steam turbine, provided sufficient exhaust steam is not given by the engines. The exhaust steam turbine is connected to a surface condenser. With the condenser, motor driven centrifugal pumps are installed to care for the circulating water and condensation. The circulating water is discharged into a cooling tower which is located on the roof of the power-house. This combined system of exhaust steam turbine and non-condensing engines forms a very economical arrangement.

The smokestack is of radial brick construction, with an inside diameter of 11 ft. and 10½ ft. at base and top respectively; its top is 245 ft. above the boiler room floor or 227 ft. above the street. Its lightning protection consists of four points (with 24-in. platinum tips) and two ⅞-in. stranded copper conductors with copper ground plates and lightning indicator device.

There are three vertical cross compound Corliss engines of 1,150 HP., each connected directly to a 750-KW. generator; also a low-pressure steam turbine with 500-KW. generator. Space is provided for an additional engine-driven unit and turbine driven unit. Supplementary to this 250-volt direct current generating plant are two 500-KW. motor-generator sets for converting the 220-volt direct current to 6,600-volt three-phase 60-cycle current for subway lighting, signals, and yard service. The motors installed at the power-house and throughout the station aggregate about 780 HP. The plant includes also two two-stage cross-compound air compressors, each with a capacity required to compress 500 cu. ft. per min. to 100 lbs. pressure. The compressed air is used for charging the air-brake reservoirs on trains.

In the boiler room in the main building, there is installed a garbage destructor, manufactured by the Morse-Boulger Destructor Co. This has a flue which connects directly with the stack, carrying off all the noxious and disagreeable odors caused by the combustion of refuse. The destructor is 14 × 6 ft., and 6 ft. high; it has a capacity of destroying four tons of miscellaneous garbage and refuse in 24 hours.

All lighting in the building, trainshed and yard is by tungsten incandescent lamps (with globes or shades); no arc lamps are used. In the post-office sub-station there are a number of Cooper-Hewitt mercury lamps. For the indirect lighting in the main waiting room the lamps are arranged behind suitable screens on the north and south cornices or ledges. City water is used for domestic service. The ventilation of the building is effected mainly by air discharged into the rooms by fans; this can be heated in winter to maintain an average temperature of 70° F., and in summer it can be cooled to 6 or 8° below outside temperature.

Approaches.

The station is approached by two separate divisions, as already noted. The approaches to the old Kinzie St. station were at the street level for some distance, but at about a mile from the station the track elevation work commenced. The new station necessarily had its tracks elevated, and in designing the new approaches it was decided to build these independently, partly to give better access to the station and partly to avoid the interruption to traffic due to elevating and widening the old approaches under heavy traffic. Each approach therefore swings off from the old line, and then runs parallel with (but at some distance from) the latter. These new approaches were described in our issue of Oct. 18, 1906.

These elevated approaches consist of solid filling between concrete retaining walls and abutments; with solid-floor steel bridges over the streets. From the junction with the six-track approach or throat at the entrance of the station, one four-track approach extends north to connect with the Wisconsin Division at Division St. (1.3 miles), and another extends west to connect with the Galena Division at Noble St. (1 mile). The tracks are about 18 ft. above the street level. The concrete walls are of gravity section, built in sections upon a continuous concrete base supported on piles. They are of gravel concrete (1:2:5) with pieces of steel rails to connect or bond adjacent sections and with steel rails as reinforcement in the base. The maximum height of wall is about 25 ft.

The bridges are mainly of the self-supporting trough-deck system with ballasted floors, as used on other track elevation work on this railway and described in our issue of Sept. 7, 1905. The trough spans are supported by cross girders on columns at the curb line and also (in some cases) in the middle of the street. For long spans or skew crossings through plate girder spans were used, having a solid floor of transverse I-beams.

In both cases the troughs (longitudinal or transverse) are filled with concrete, this being a wet mixture of 1:2:4 proportions. This extends above the troughs so as to form a continuous sheet of concrete, and upon this is the waterproofing layer. This waterproofing is very important, in order to avoid complaints from water dripping in the subways. The method adopted was similar to that employed for the trainshed floor, described above. After the concrete had set thoroughly, it was first cleaned and then covered with a binding concrete to fill the voids and make a dense surface. When this was dry, a heavy coat of hot asphaltic composition was applied with mops and 40-in. strips of burlap were laid in this and well mopped with asphalt. There were four coats of the composition and three layers of burlap, the joints of the latter being so as to form a continuous sheet covering the entire width and length of the floor. The surface was then finished with two ¾-in. layers of hot sand-mastic, composed of 1 part asphaltic composition and 4 parts clean sand.

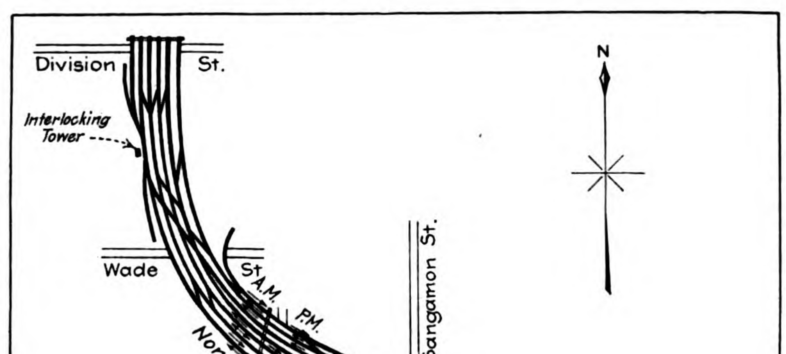


FIG. 10. GENERAL PLAN OF TERMINAL AND APPROACHES, SHOWING THE ARRANGEMENT OF TRACKS AND THE LOCATION OF SIGNAL TOWERS AND BRIDGES.
(Not to Scale.)

A Prepared Filler for Macadam Roads.

By CHARLES H. HOYT, C. E.*

Previous to the use of the method of applying bituminous binders during the construction of macadam roads, as described herein, there were two general methods of application used in this country—generally known as the "penetration" and the "mixing" methods. This new scheme the author has called the "prepared-filler" method. The mixing method, while admittedly the more thorough of the two, has been considered too expensive to be adopted generally in highway construction. The penetration method has had the advantage of being more convenient by requiring less outfit for its application, faster in its manipulation, and also somewhat cheaper in first cost. This method, while much used, has, however, not been altogether satisfactory.

The method of constructing bituminous macadam by the use of a prepared filler is new in this country. It combines practical convenience in manipulation with thorough construction, and falls between the other two methods referred to in first cost. In fact, it can be built for very nearly the same cost as the penetration method.

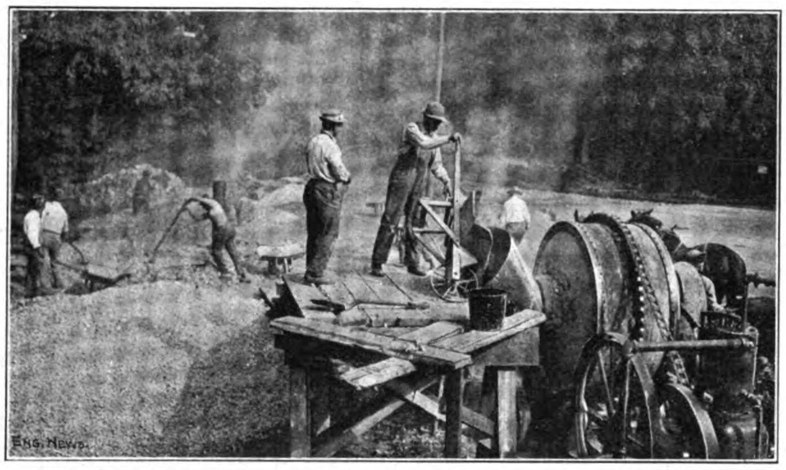


FIG. 1. MIXING PREPARED FILLER FOR MACADAM ROADS.

The ordinary "water-bound" macadam served its purpose for many years—until traffic conditions changed and became more severe, thus requiring a more tenacious road surface to resist the forces that come upon it. In the destruction of a water-bound macadam surface by the rapidly moving vehicles and hoofs, the larger stone are not removed first, but the screenings and smaller material are pulled or pushed out of place, leaving the larger stone loose, which results in a rough and ravelled patch, which grows in size.

The prepared-filler method seeks to remedy this condition by coating this fine material, which has heretofore been disturbed, with a bituminous binder, before it is placed in the road around the larger stone. In this way the larger stone are bound and held in a matrix which is difficult to remove.

The actual construction is carried out very much the same as if plain water-bound macadam were being built. That is, the foundation course is exactly the same as for a plain macadam; then the top-course stone, varying in sizes from ¾ to 2 ins., is spread evenly to a depth of 3 or 4 ins., as may be specified for the depth of the top-course stone while loose.

The next step, taken while the top-course stone is still loose, is to apply a layer of prepared filler spread evenly over the top stone to a thickness equal to about 0.4 to 0.5 the depth of the layer of loose top course.

The prepared filler is made in the following way: To one volume of stone chips, or pea gravel, varying in sizes from ⅛ to ¾-in., is added about 40%, by volume, of clean sharp sand, and from 10 to 15%, by volume, (of stone chips or gravel only) of bituminous binder, which may be of any kind or quality that would be used by the penetration or mixing methods, although it would probably be of no advantage to use by this method the lightest grades of those binders that are specified for the penetration method.

The stone chips (or pea gravel), sand and bituminous binder are heated, or not, as may be required to secure a uniform mixture. Then they are thoroughly mixed together either on a board with shovels or in a machine mixer.

After the layer of prepared filler has been spread over the top course of stone, it is then worked down into that course by rakes, or by harrowing with a light steel spike-toothed harrow whose teeth are about ½-in. square, set close together and about 3 ins. long. The harrowing should continue only until the top-course stone begins to appear generally throughout the layer of the prepared filler. Then the surface is rolled with a 10-ton roller until it is firm.

More of the prepared filler may be sprinkled over the surface to cover bare spots which develop as the rolling progresses. If desired, after the first rolling has been finished, a surface coat of the prepared filler, about ¾-in. in thickness, may be applied and the surface re-rolled.

Two sections of road—one 50 ft. long, the other 75 ft. long and 16 ft. wide—were built by this method, under the supervision of the writer, last September at Ithaca, N. Y., on East Ave., passing Cornell University campus. On the 50-ft. section, after the first rolling had been finished, a paint coat of about ½-gal. per sq. yd. of oil asphalt was applied and covered with stone chips. On the 75-ft. section a surface coat about ¾-in. thick of the prepared filler was applied, as described above. An oil-asphalt binder was used for the 50-ft. section and a "cut-back"-oil asphalt was used for the 75-ft. section. Typical views of various stages of the work are shown in the accompanying figures.

Reports from this roadway show that both sections are in good condition. The 75-ft. section, which had more of the prepared filler applied and had also a ¾-in. wearing surface of prepared filler, is showing up much better than the 50-ft. section which had a smaller amount of filler in the top course and had also only a paint coat of bitumen on the top. This is in accord with the writer's expectations. In fact, the whole idea of the scheme was to get rid of applying the bitumen from hods, sprays, or like appliances, either as a paint or a first coat.

The writer believes that this method has very strong features in its favor as a practical method of building bituminous-bound macadam. No ruts appear in the sections built at Ithaca and there is no evidence of water having collected between the bituminous-bound and bottom courses of stone.

Before the Ithaca strips were built, there was considerable doubt about being able to harrow the material into the top-course stone. It was thought by some that it would be necessary to make the filler of such lean proportions that it would not form a strong enough matrix. These predictions have not come true. In fact, on the 50-ft. section, which was the first one built, the material was harrowed in too deep—which may account for that section not showing up as well as the 75-ft. one which was harrowed much less.

The bitumen can be mixed with the stone chips and sand much more uniformly than when applied by any penetration-method apparatus which the writer has yet seen. The amount of bitumen to a square yard of road can be controlled perfectly by using more or less sand. The more sand used the more pliable is the prepared-filler mixture.

By using the proportions of materials stated for the prepared filler—that is, one volume of the stone chips or gravel, 40% of sand, and 10% of bituminous binder—a layer 1 in. thick over 1 sq. yd. requires the following amount of material:

0.028 cu. yd. of chips;
0.0112 cu. yd. of sand;
0.0028 cu. yd. of bitumen,
or 0.567 gal. per sq. yd.

If 15% of bitumen is used, then 0.85-gal. per sq. yd. is required. Assuming that a layer of the prepared filler, 2 ins. in depth, is used, the 10% filler will require 1.134 gals. of bitumen per square yard of road surface, and the 15% filler will require 1.7 gals.

FIG. 2. PREPARED FILLER SPREAD OVER TOP-COURSE STONE; BEFORE HARROWING.

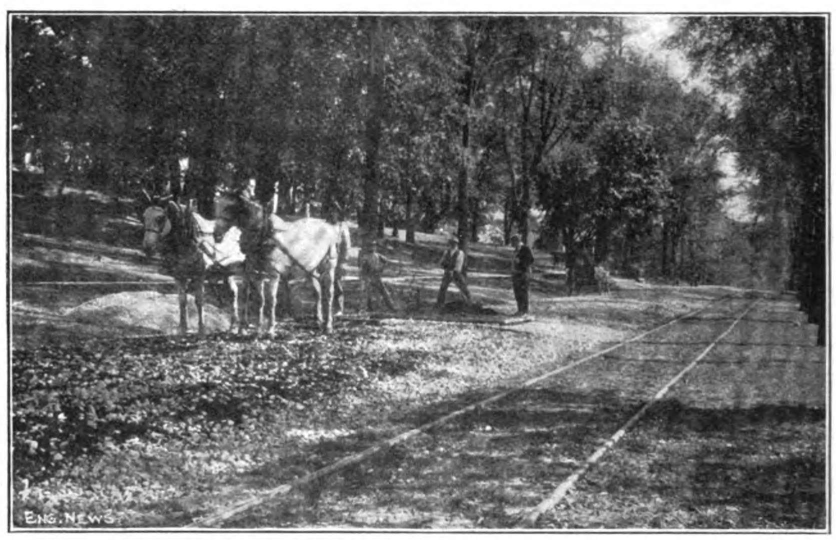


FIG. 3. SPREADING AND HARROWING PREPARED FILLER.

*Superintendent of Road Construction, U. S. Office of Public Roads, Washington, D. C.