Convention Number

Electric Railway Journal

An Account of Recent Progress in Electric Railway Track Construction, Power Generation, Car Design, Repair Shop Methods, Fare Accounting, Freight Handling, Signaling and the Independent Propulsion of Cars

TRACK CONSTRUCTION

THERE is a marked difference of opinion among engineers as to the best form of track foundation. Some consider that absolute rigidity is necessary to durability, while others are of the opinion that some degree of elasticity is desirable for both track and rolling stock. While the exact causes of rail corrugation are unknown, it is generally admitted now that the rigid track construction is an important factor in its production. If this theory is correct, at least one element of durability in track will be obtained by an elastic foundation. In this chapter both methods will be described, and an attempt will be made to present in the text and by illustrations a summary of the recent progress made in solving other problems involved in the work of track construction in paved streets.

EXCAVATION AND DRAINAGE

No small part of the cost per linear foot of track is spent for excavation, and since the abandonment of the concrete beam most companies make a trench of uniform width and depth for the track. This is little, if any, more expensive than where the excavation is carried to a greater depth below the ties than between the ties, because such special excavation has to be done by hand labor, whereas the uniform trench can be made with power excavators. However, some companies have been successful in reducing the amount of excavation by the use of shallow rails and short ties (6 ft. 8 in. or 7 ft.) and reports indicate that this practice is satisfactory.

Closely connected with the subject of excavation is that of drainage, and before any design for track in paved streets is complete the subsoil should be carefully investigated so that its bearing qualities and its drainage characteristics may be determined. Some qualities of clay will retain water indefinitely and must be provided with a drainage system, especially where crushed-stone ballast is used in the place of solid concrete. The methods employed in providing artificial drainage for the track foundation are as follows: The tile is laid in a trench in the space between the ends of the ties in double track, or it is installed under the center of each track. In either case it is good practice to slope the subgrade to the drain and provide frequent outlets and a filtering medium around it. Some engineers make this filtering medium of cinders, some employ gravel and crushed stone, and still others use a form of roofing gravel.

Neutral Strip for Suburban Track Construction, Memphis Street Railway

An ordinary 6-in. clay drain tile is generally used for this purpose, but the experience of some engineers tends to show that it is practically impossible to keep such a drain clean, regardless of the care with which it is laid, both as to grade and provision for outlets. To obviate this difficulty either first-grade or second-grade vitrified tile provided with bell and spigot has been used. This kind of tile is laid with unsealed joints, each joint being surrounded with the filtering medium of cinders, crushed stone or roofing gravel. This type of construction has been found just as effective as the soft tile, and in addition it is self-cleaning and will withstand greater pressures without being crushed.

Another phase of the trench construction worthy of careful consideration is its preparation to receive the concrete or ballast foundation. One method frequently adopted is to roll the subgrade with a 10-ton or 15-ton roller to give it uniform bearing qualities. Other engineers have considered this method of preparing the subgrade unnecessary, particularly where the excavation is made through clay in its original state. In some localities the soil often contains soft spots or sink holes, and to obviate future difficulties these soft spots should be dug out and filled with concrete. When a trench is excavated through made ground its bearing power is a questionable quantity. To provide against failure at these points, the depth of the concrete base should be increased so that it will act as a floating foundation.

CONCRETE FOUNDATIONS

In the early days, and in some instances at the present time, the use of concrete for foundations has been required by city engineers. In the past its quality has often been considered a secondary matter, but with the wider adoption of concrete for foundations in track construction, the proper materials as well as the proportions are now receiving more thoughtful consideration. As a rule, it is safe to say that bank-run gravel will not produce the best results in track foundations, as it is seldom free from foreign matter. The proportion of foreign matter in the ingredients has a direct bearing on the quality of concrete produced, and experience has shown that the best results are obtained where the quality of concrete is at least equal to that used in the better class of foundations. Doubtless the best results will be obtained when the aggregate is carefully analyzed to determine the percentage of voids, both as to sand and cement, washed materials being preferable to dry screened.

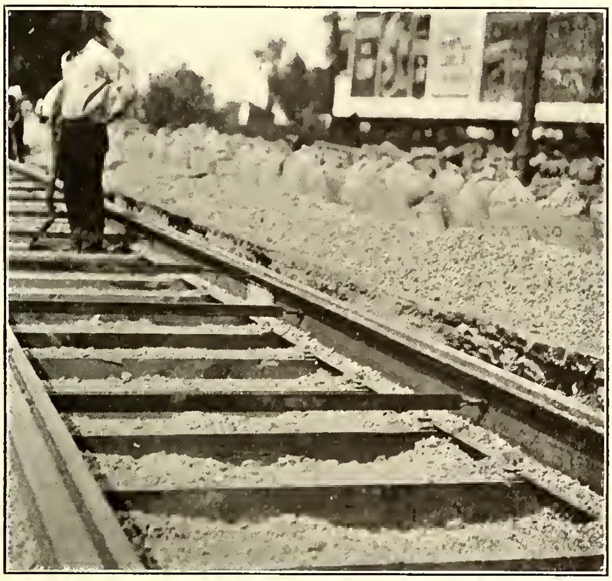
The proportions of cement, sand and aggregate employed by the various street railway companies throughout the country vary from a mixture of 1:3:7 to one of 1:2:4. The best practice is to regulate the mixture of sand and aggregate at some central point, preferably before it is delivered to the construction work. Where this method is adopted the foreman of the concrete mixing gang may devote his entire time to seeing that the concrete is properly mixed and then that it is laid in the proper way, rather than to be required to give a part of his time to seeing that the materials are mixed in the proper proportion.

As a rule a 6-in. concrete foundation placed under the tie or under a sand or crushed stone cushion immediately below the ties has been accepted as desirable. Some engineers have found this depth inadequate owing to local soil conditions and have increased the depth to 8 in., particularly where the resilient type of track construction is employed. In any type of construction where concrete is employed as a foundation the aggregate is

Standard Girder Grooved Rail Construction, Public Service Railway of New Jersey

usually deposited as wet as practicable and should be well puddled so that all voids are filled.

Where it is impossible to divert traffic from a track being rehabilitated some engineers have adopted the plan of installing crushed-rock foundations temporarily, to be



Type No. 3 Track of Chicago City Railway After Tamping Ballast

followed by concrete. After the rock has been tamped thoroughly and the weak spots revealed by operating regular service over the open track, a rich grout mixture is poured into the voids. While this method has not been

Plastering the Rail Before Paving Is Begun, Chicago City Railway

tested generally, and while the concrete has not been in service long enough so that conclusions may be drawn as to its practicability, it appears that in an emergency it is a desirable plan to follow.

One of the difficulties in solid concrete track construction is to provide a perfect track surface. As a rule the track is lined and surfaced with wood blocks, and the concrete is poured in around the ties up to paving foundation level. As the concrete sets and the moisture evaporates from the tie, the concrete is apt to shrink away from

Grouted Paving Along Rails with Space Between Ready for Asphalt Filling, Chicago City Railway

the tie, particularly if it is untreated, and this leaves the track supported only on the blocks. When traffic is turned on to the track the blocking settles until the tie bears on the concrete. This starts a movement

Track with Rail Anchors Ready for Concrete, Houston Electric Company

between the tie and the concrete which increases with age.

Another common error which engineers make when they have to hurry to turn over a section of track to the transportation department is the failure to give sufficient time for the concrete to set properly. From at least ten days to two weeks should be allowed for this during the summer months and the time should be extended when the temperature is lower, particularly when track is being constructed in the late fall.

BALLAST

Ballasted track is used quite generally by some engineers for track foundations in paved streets where it is impossible to divert traffic while the construction is under way, and it is also used by other street railway companies in preference to a concrete foundation so as to obtain more resiliency. The procedure in Chicago is a notable example of the latter, as it is now using the ballasted type of track construction almost exclusively. Its general adoption in Chicago was largely the result of the difficulty which the street railways there experienced with the rapid development of rail corrugations and their efforts to eliminate this common but inexplicable phenomenon.

ballast is 6 in. Some engineers, however, have made the depth as shallow as 5 in., and others have increased it to 9 in. The question of draining this type of track construction does not appear to have received serious consideration, as comparatively few companies have provided tile drains either under the center of each track or in the space between the ends of the ties in double track.

In connection with the use of crushed rock or gravel for ballast under track in paved streets, the types employed by the Milwaukee Electric Railway & Light Company and the Twin City Rapid Transit Company, which are somewhat similar, have been found to produce as permanent a track as may be desired. Coarse crushed rock or gravel is employed in both designs and is placed in the trench to a depth of 6 in. and thoroughly rolled in place by a road roller, Over the top of this sub-ballast layer the Milwaukee Electric Railway & Light Company

Girder Grooved Rail on Combination Ballast and Concrete Foundation, United Railroads of San Francisco

spreads 2 in. of No. 2 medium crushed stone, which is used in surfacing and tamping the track to finished grade. The Twin City Rapid Transit Company's design requires that a 2-in. layer of fine gravel be spread over the top of the crushed rock ballast, which also serves for surfaceing and tamping the track to a finished grade. In Baltimore 6 in. of ballast is used under the ties, and in many cases gravel is used between the ties.

To reduce the quantity of concrete necessary to construct its track in paved streets, the United Railroads of San Francisco, Cal., in addition to placing 9 in. of rolled crushed rock ballast under the ties, spreads mounds of crushed rock between the ties at the track center and between parallel double tracks. This mound or ridge of crushed stone is so placed as to permit the paving foundation concrete to form a beam under the rail of the same depth as the tie. The top of the ridge or mound of crushed stone projects approximately 2 in. above the top of the tie.

With this type of construction the most permanent results are obtained by the use of a crushed stone of first quality and of a size to pass through a 2½-in. ring. This stone is screened to remove the fine particles which, after the ballast is in place, tend to filter out with moisture, causing a shifting roadbed.

Construction of this character compares vary favorably with that where a concrete foundation is used if the installation has been thoroughly guarded. Where subsoil conditions give evidence of instability, however, ballasted track construction should not be employed. It is objectionable in instances of this character because crushed stone does not act as a unit in a way similar to a solid concrete slab, but the load on each tie is carried to the subgrade independently. Hence, if there is the slightest giving way in the subsoil, the track begins to pump, and this finally results in its utter failure to maintain a uniform line and surface.

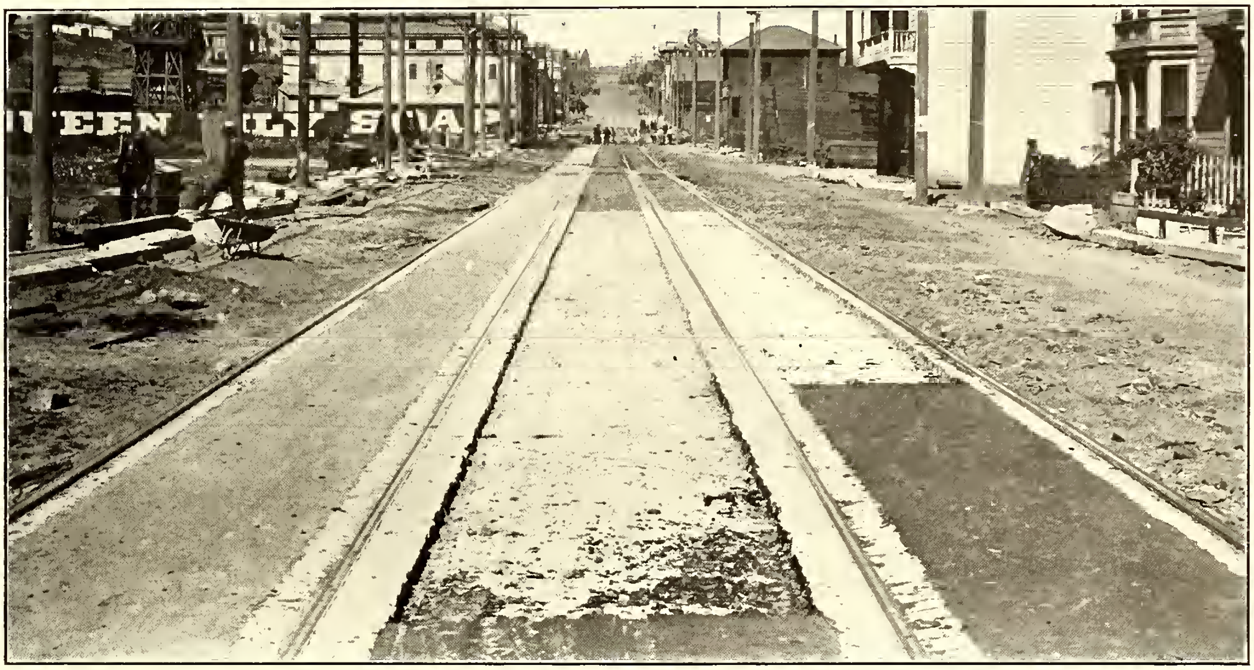
As a rule, the depth of this crushed stone or gravel

TIES

If the axiom that the life of the track is equal to the life of the joint is accepted, the next element of success entering into its make-up is the tie, which is subject both to decay and mechanical wear. Ties of various lengths and of various kinds of timber are being used in different parts of the country, namely, the chestnut and hard woods in the East, principally hard woods such as mixed oak and white oak in the Central States, long-leaf yellow pine and cypress in the Southern States and some of the Central States, and practically all yellow pine and fir in the Western States.

Reports from more than thirty of the principal street railway properties in the United States show that less than one-third of them are using treated ties. Some engineers have taken the position that the life of the tie should not exceed the life of the rail. Consequently they have adopted ties which will give this length of life in service, and usually the kind of timber selected is that most plentiful in the territory in which the street railway company's property is situated. On the other hand, some engineers have used treated soft wood, only to find its life limited by mechanical wear. Consequently they have abandoned its use, adopting a more expensive untreated timber which will give the same length of service. Where the selection of the kind of tie to be employed is not governed by either of these factors and the engineer is free to approach the problem with an open mind, he usually adopts either the treated hard wood or the white oak tie. In either case he is careful to see that the timber is properly seasoned before it is treated or before it is placed in the track. If the tie is untreated, usually the specifications limit the percentage of sap wood, and only sound timber up to specified sizes is employed.

There has been considerable discussion as to the advisability of using hewn or sawn ties either treated or untreated, and the problem still remains an open one. Doubtless for treated ties sawn timber will give better penetration in the treating process than hewn ties. When a stick of timber is squared the saw does not follow the grain but leaves the pores open to receive the preservative under either the pressure process or the dipping or painting process. To verify this statement one needs only to cut into a sawn tie and a hewn tie treated by the same process, and it will be found that the penetration in the sawn tie is much deeper than that in the hewn tie. The fact that a better rail bearing is obtained without adzing is another argument in favor of sawn ties. To provide an equal bearing area on hewn ties it is necessary either to adze them by hand after the rail is set in position, just before it is spiked, or do the surfacing with an adzing machine at the material yard. This latter method is practised by the United Railways of St. Louis in conjunction with the use of screw spikes and tie plates. All 6-in. x 8-in. x 7-ft. white-oak hewn ties are both machine-adzed and drilled for the plates and screw spikes at the material yard.



Girder Grooved Rail with Combination Granite Block and Asphalt Paving, United Railroads of San Francisco

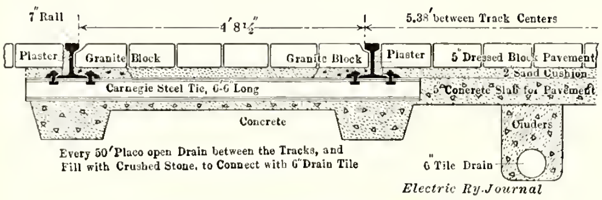
Preservative plant engineers have been endeavoring to obtain a uniform treatment throughout the cross-section of the timber, but experience has shown that this is unnecessary, it being merely a theory based on the old adage "If little is good, more should be better."

Specifications for ties and their treatment should be prepared with care and strictly carried out. The best method of accomplishing this is for the purchaser to place a competent inspector at the tie yard or treating plant, preferably at both places. As a rule, neither the tie company nor the treating plant has the slightest objection to the company's inspecting the work under way. They would rather have a large percentage of ties refused before they have been transported to destination than a small quantity after they are delivered.

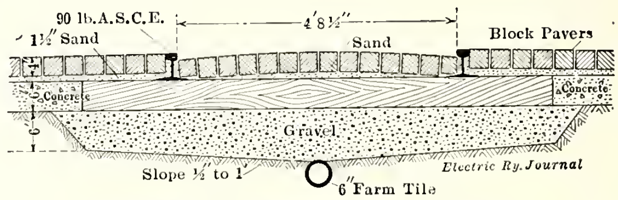
Usually the engineer for a street railway company is unaware, until a comparatively short time in advance, of just how much track he will have to construct during any year. In most instances the amount to be built depends

its orders until the material is actually needed it may be delayed in beginning the work owing to the slow delivery of rails and ties.

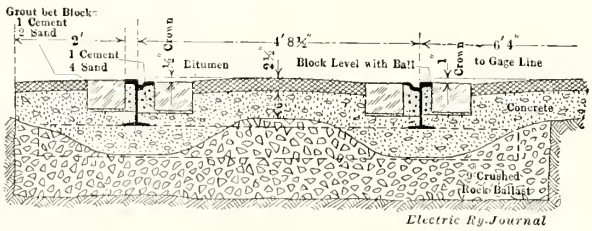
To cope with this problem, a number of companies have made it a rule to set aside a considerable area in their material yards for the storage of these materials.



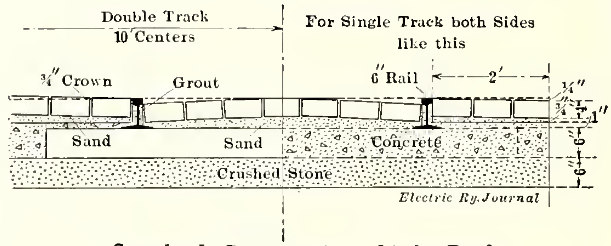
Standard Construction, Cleveland



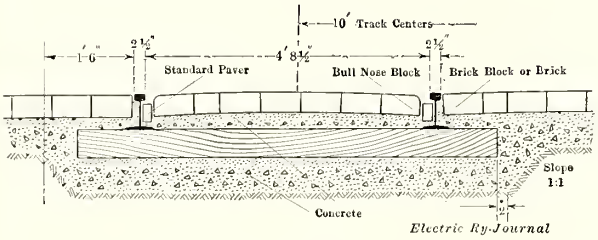
Standard of Illinois Traction System



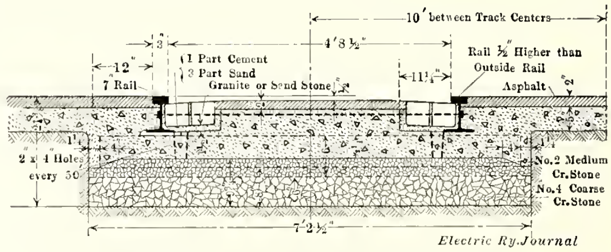
Standard Construction, San Francisco



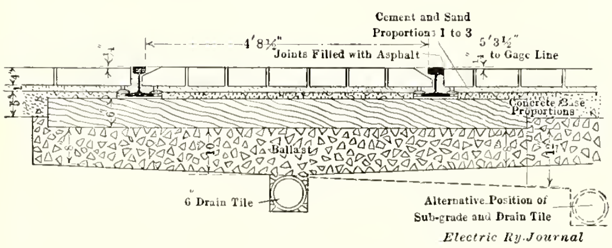
Standard Construction, Little Rock



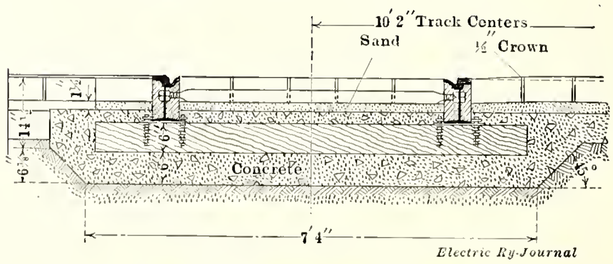
Standard Construction, Seattle



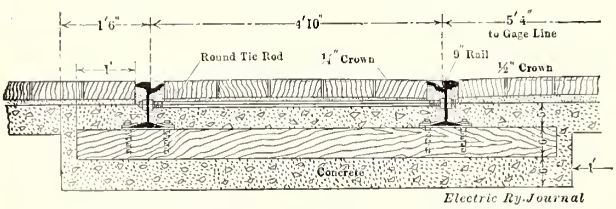
Standard Construction, Milwaukee



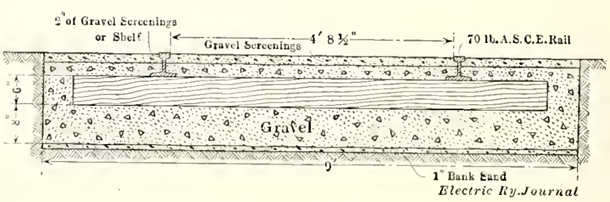
Standard Construction, Kansas City



Concrete Construction, Chicago



Standard Construction, St. Louis



Gravel Ballast Construction, Houston

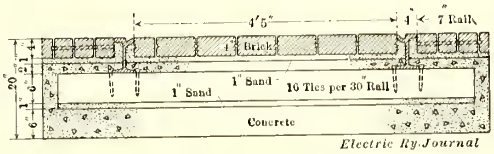
largely upon the action taken by the city administration in regard to paving. If a new pavement should be ordered for any street, the street railway company will usually want at the same time to rehabilitate its tracks on that street. To do this promptly, however, it must have its track materials on hand, because if it waits before placing

If the ties are purchased in large quantities regardless of the seasoning and sufficiently in advance of their use in track work, it is possible for the company to be certain of the seasoning by doing it in its own material yard. In addition to providing exact knowledge of the period of seasoning, the fact that the ties are purchased in large quantities in a field in which competition is sharp brings about a reduced price which, in many instances, offsets the fixed charge on the investment on ties lying in the material yard.

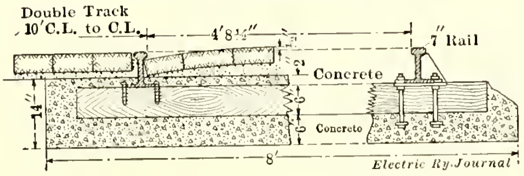
Many street railways have adopted the 6-in. x 8-in. x 8-ft. tie, spaced at 2-ft. centers in the track, as in standard steam road practice. On quite a number of street railways, however, a 7-ft. tie has been adopted in place of an 8-ft. one, and on the Detroit (Mich.) United Railways a 6-in. x 10-in. x 6-ft. 8-in. white-oak tie is used exclusively. It has been found that when odd lengths or sizes are purchased in large quantities usually the standard price holds. It is claimed for the tie with the 10-in. width used by the Detroit United Railways that it not only gives additional bearing area but increases the strength of the tie at the center, where it is desired.

Under special work, such as turn-outs and cross-overs, the ties in some cases conform to the standard, being 6 in. x 8 in. in section, but most street railways are purchasing them of special lengths so as to eliminate the difficult tamping experienced with the standard-length ties interlaid to meet track conditions.

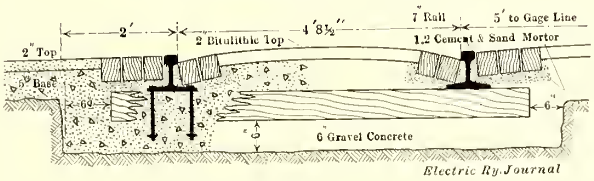
Several railways have adopted a close tie spacing on ballast foundations, while others have increased the in-



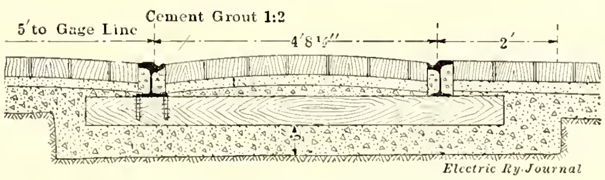
Standard Construction, Detroit



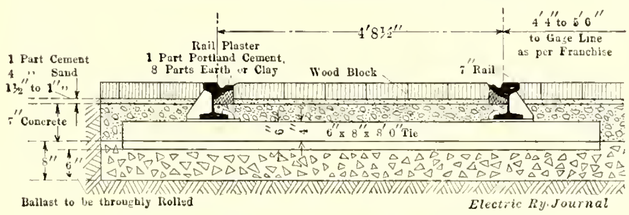
Concrete Construction, Houston



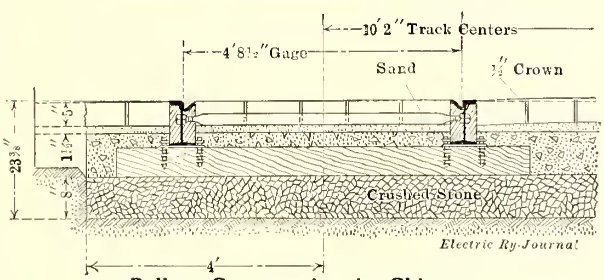
T-Rail Construction, Dallas



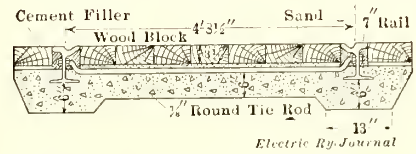
Girder Rail Construction, Dallas



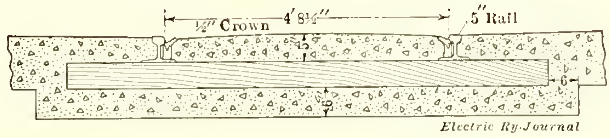
Standard Construction, Newark, N. J.



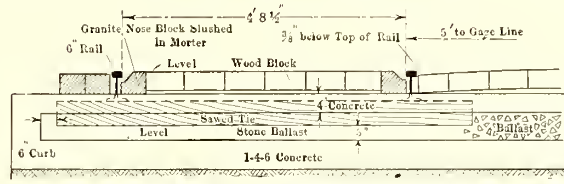
Ballast Construction in Chicago



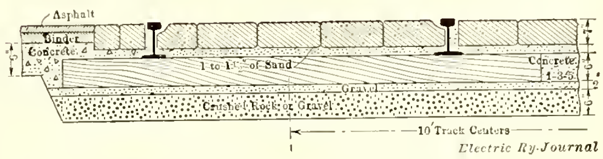
Girder Rail Construction, Memphis



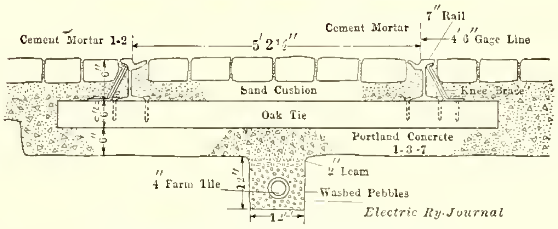
T-Rail Construction, Memphis



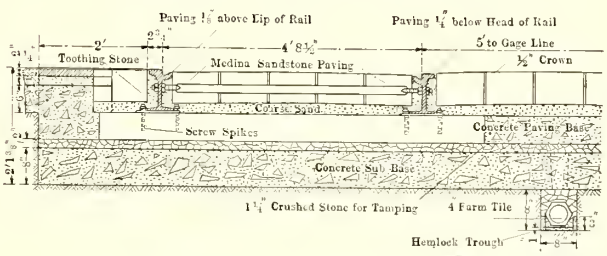
Standard Construction, Toledo



Standard Construction, Minneapolis



Standard Construction, Cincinnati



Standard Construction, Buffalo

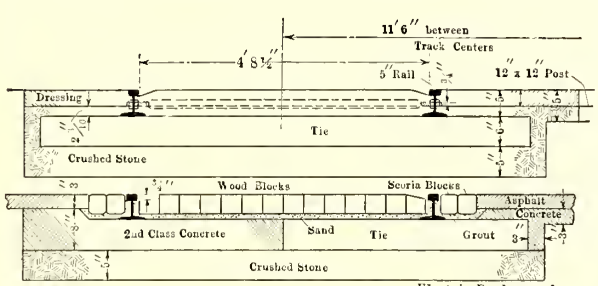
Characteristics of Track Construction in Paved Streets in Thirty-six North American Cities

City	Roadbed Under Ties	Ties			Rail		Spikes	Joints				Bonds	Tie Rods	Rail Braces and Tie Plates
		Spac'g	Kind	Size	Type	Wt.		Type	Drill'g	Lgth.	Bolts			
Baltimore	6" ballast under ties	2'0"	Wood	6"x8"x8'	9"&7" gird.gr've	103	Screw	Riveted-welded	10-hole	32"	1" riv'ts	None	⅜"x2", 6' centers	Tie plates.
Birmingham	6" 1:3:6 slag concrete	3'4"	Creosoted pine	6"x8"x7'6"	7" T-rail	80	9/16"x5½"	Continuous	4-hole	24"	⅞"	Com.ter.and ball	None	Tie plate and rail brace 6'8"
Boston	6" trap rock—1:2:5 con., width 3½", cr.-r'k cushion	2'0"	Long-leaf pine	6"x8"x8'	9" girder 7" girder	132 116	½"x¾"x6⅛" Screw	Electric-welded	None	......	None	None	1" r'd & 2¼"x 13/32" flat, 5' centers	Tie plates on all ties
Buffalo	8" 1:3:5 grav.—concrete with 2" sand cushion	2'0"	Long-leaf pine	6"x8"x7'	9" girder groove	124	Screw ½"x¾"x6⅛"	Continuous	4-hole	24"	1"	2-4/0 compressed terminal	5/16"x2", 6' centers	Plates on all ties
Chicago	8" crushed-stone ballast	2'0"	Yellow pine & creosoted oak	6"x8"x7'	9" girder groove	129	Screw ½"x¾"x6⅛"	Electric-welded	None	......	None	None	5/16"x2", 6' centers	Tie plates ¼"x6 x10"
Cincinnati	6" 1:3:7 rock conc., 4" farm drain in center	2'0"	White oak	6"x8"x8'	9" girder groove	140	9/16"x5½"	Cast welded	....	13"	....	None	None	Rail brace at fourth tie
Cleveland	6" 1:6 gravel conc. under tie & 12" under rail	4'0"	Carnegie steel	6'6" long	7" T-rail	95	Bolt and clip	Clark joint	8-hole	30"	1⅛"	None	⅜"x2", 5' centers	None
Dallas	6" 1:7 gravel concrete, 6" 1:3:6 rock concrete	3'0"	Hd. pine, drop anchs.ev.2d tie	6"x8"x7'	7" T-rail 7" gird. groove	80 103	9/16"x5½"	Continuous	6-hole	26"	1"	2-9" crown pin	None	Brace plates every third tie
Detroit	8" 1:2:4 grav. conc., 1" sand cushion under ties	3'0"	White oak	6"x10"x6'8"	7" T-rail	91	9/16"x5½"	Cast welded	None	......	None	None	⅜"x1½", 6' centers	None
Harrisburg	6" cr. r'k ballast under ties	3'0"	Chestnut	6"x8"x7'6"	9" tram	125	9/16"x5½"	Continuous	6-hole	26"	⅞"	Comp'd term'l	⅜"x2", 10' cen'rs	None
Houston	6" 1:3:6 rock concrete	5'0"	Pecky cypress. Anc. bet. ties	6"x8"x7'	A.S.C.E. 7" T-rail	80 80	Screw	Bonzano continuous	6-hole 6-hole	26" 26"	1" 1"	2-4/0 pin driv'n	None	Rail brace every 10'0"
Ill. Trac.	8" grav. ballast	2'0"	Creo. white oak	6"x8"x8'	A.S.C.E.	90	9/16"x5½"	Continuous	6-hole	26"	⅞"	Comp. term.	None	None
Indianapolis	6" to 10" 1:2½:5 gravel concrete under ties	2'0"	White oak	6"x8"x8'	7" T-rail 9" tram	91 95	9/16"x5"	Cast welded and continuous	....	......	None	Brazed and comp. term'l	⅜"x2"	None
Kansas City	8" to 12" crushed rock ballast under ties. Tile drain	20"	White oak	6"x8"x8'	A.S.C.E. 9" Trilby	100 109	9/16"x5½" Screw ¾"x5½"	Continuous	4-hole	24"	1"	Comp. terminal and soldered	⅞" round	Tie plates with screw spike
Little Rock	6" crushed stone	2'0"	Creosoted pine, sawed	6"x8"x8'	6" T-rail 7" tram girder	72	9/16"x5½"	Angle-bar continuous	6-hole 4-hole	34" 24"	⅞" ⅞"	2-4/0 soldered	None	None
Louisville	6" crushed stone concrete	2'½"	Steel ties, oak ties	4¼"x6'6" 6"x8"x8'	9" Trilby	106	9/16"x5½"	Bars	....	......	1" but. h'd	2 flexible, compress'd term'l	Flat, 2"x⅜" & ⅞" round	None
Los Angeles	....	20"	Redwood	6"x8"x8'	9" Trilby 7¼" T-rail	116 87	9/16"x5½"	Continuous and thermit	....	......	....	....	....	Every fourth tie
Milwaukee	6" No. 4 crushed rock and 3¾" No. 2 crushed rock	2'0"	Long-leaf yel. pine, wh. oak	6"x8"x7'	7" T-rail	95	¾"x⅞" Screw	Cast welded & bar	6-hole	28"	1⅛"	....	2"x5/16", 6' centers	None
Memphis	6" crushed rock concrete	5'0"	Creo.pine ties	6"x8"x8'	T and 7" Trilby	80 105	9/16"x5½"	Cast and bar	8-hole	34"	1"	Com. ter. and brazed	⅞" round	None
Minneapolis	6" rock ballast with 2" gravel under ties	2'0"	Oak or pine creosoted	6"x8"x8'	7" T-rail	91	9/16"x5½"	Cast welded	1-hole	......	None	None	⅜"x1½", 10' centers	None
Montreal	8" 1:3:6 rock concrete, 1" sand cushion under ties	2'0"	Pine and cedar	6"x8"x8'	7" Trilby	116	9/16"x5½"	Continuous	6-hole	26"	1"	Electric brazed	13/16" rod, 6' centers	None
Newark	6" crushed rock or slag under ties	2'0"	Long-leaf pine, creosoted	6"x8"x8'	7" Trilby	116	9/16"x5½"	Bonzano continuous	4-hole	24"	⅞"	Compressed terminal	None	Tie plates on every 2d tie
New Haven	Natural gravel ballast in subsoil	2'0"	White oak and chestnut	6"x8"x8'	7" T-rail 9" gird. groov'd	95 125	9/16"x5½"	Continuous bar	4-hole 12-hole	24" 32"	⅞"	....	None	Only on curves
Philadelphia	18"x19" concrete stringer	4'0"	Cast-iron chair	....	9" Trilby	141	Bolt and clip	Nichols joint	None	......	1" riv'ts	None	None	None
Pittsburgh	8" stone ballast under ties	2'0"	....	6"x8"x8'	9" Trilby	125	9/16"x5½"	Bars with reamed holes	....	......	Machin'd	Comp. terminal & ther. welded	⅝"x2"	....
Portland, Ore.	6 to 8" gravel ballast under ties with tile drain	2'0"	Fir	7"x9"x8' 6"x10"x6'	7" groove 7" T-rail 6" T-rail	95 80 72	9/16"x5½"	Continuous	4-hole	24"	1"	Compressed terminal	None	None
Richmond	6" concrete	8'0"	Carnegie	4¼"x6'8"	9" gird. gr've	114	Lugs and T-bolts	Electric weld	....	......	....	None	None	Tie fast. and rail brace
Seattle	6" 1:4:7 concrete	18"	Washington fir	6"x8"x7'	7" T-rail	90	9/16"x5½"	Continuous	6-hole	26"	1"	4/0 and 500,000 c.m., soldered	On curves 8' cen. At j'ts 30" cen.	6 8"x10"x⅜" at joints only
San Francisco	9" stone ballast under ties	2'0"	Redwood	6"x8"x8'	9" Trilby	106	9/16"x5½"	Bars	6-hole	26"	1"	⅞" comp. ter.	⅞" rod, 10' cen.	None
St. Louis	6" 1:3¼:6½ rock concrete under ties		White oak	6"x8"x8'	9" T-rail 7" Trilby	100 132	Screw	Nichols joint	....	......	....	None	⅞" rods, 6' cen.	Tie plate with screw spikes
Springfield	9"x22" concrete beam	5'0"	Steel	4¼"x6'8"	7" T-rail	70	Lugs & bolts	Continuous	6-hole	26"	⅞"	None	None	None
Toledo	6" 1:4:6 concrete and 3" stone ballast	2'0"	Sawed white oak	5"x8"x7'	6" Dudley	100	9/16"x5½"	Angle bars	4-hole	24"	1"	1-8", 4/0, braz.	None	None
Toronto	6" or 7½" 1:3:7 rock concrete under ties	5'0" or 2'6"	Carnegie steel, cedar & pine	7" long 6"x8"x8'	7" T-rail 7" T-rail	90 80	Bolt and clip 9/16"x5½"	Continuous Continuous	6-hole 6-hole	26" 26"	1" 1"	Electric welded on rail head	7" rods, 6' centers	None
Vancouver	6" 1:3:6 gravel concrete, 1" sand cushion under ties	2'0"	Fir	6"x8"x8'	7" T-rail	91	9/16"x5½"	Continuous	6-hole	26"	1"	Comp. terminal and soldered	⅜"x2", 6' centers	None
Winnipeg	3" crushed stone, 6" 1:3:5 concrete under ties	2'0"	Fir	6"x8"x8'	7" T-rail	80	9/16"x5½"	Continuous	6-hole	26"	1"	4/0 soldered to rail head	None	None
Washington	5" crushed rock.	30"	Chestnut	6"x8"x8'	A.S.C.E. titan.	80	9/16"x5½"	Continuous	6-hole	30"	⅞"	2-4/0 pin term'l	1½"x⅜"	None

terval to 3 ft. and 3 ft. 4 in. on concrete foundations. The cities where street railways employ concrete track foundations and space wooden ties wider than 24 in. include: Detroit, Mich., with a 40-in. spacing; Washington, D. C., with a 30-in. spacing; Houston, Tex., with a 5-ft. spacing in combination with a rail brace and anchor plate between the ties; Birmingham, Ala., with a 3-ft. spacing for T-rail and 3 ft. 4 in. for girder rail construction; Memphis, Tenn., and Dallas, Tex., with a 3-ft. spacing.

Very few properties use steel ties extensively; some which experimented with them have definitely abandoned them for the wooden tie. The Cleveland Railway standard track construction in paved streets includes both the Carnegie and the International steel ties, the latter being used only at joints. The Virginia Railway & Power Company, Richmond, Va., is using the Carnegie steel tie spaced at 8-ft. intervals, and the Springfield (Mo.) Traction Company has adopted the Carnegie steel tie spaced at 5-ft. intervals. In Richmond, Va., the steel tie is used with a 9-in., 114-lb. grooved girder rail, and at Springfield, Mo., and Cleveland, Ohio, it is being used with a 7-in., 80-lb. and 7-in., 95-lb. T-rail respectively.

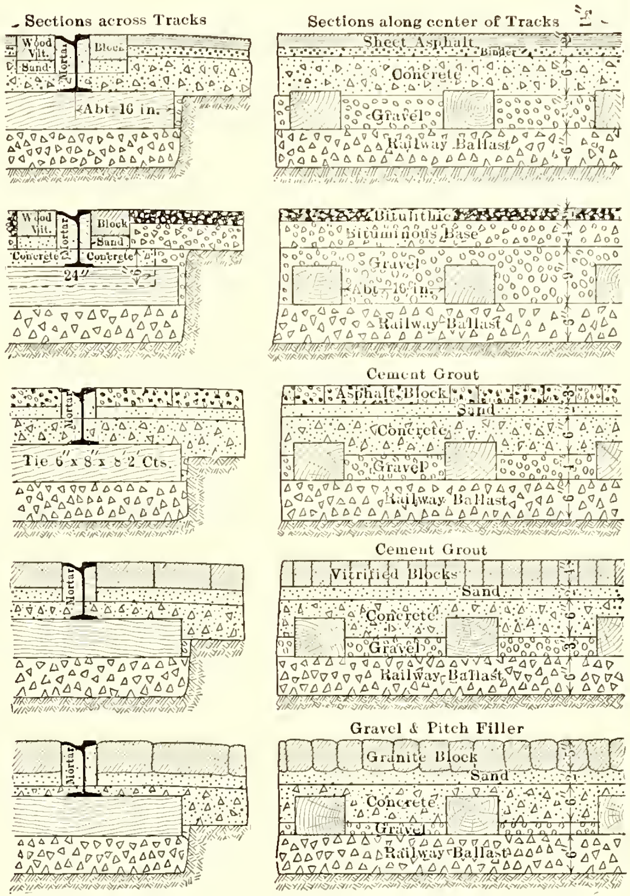
Considerable experimentation with steel ties has been conducted by the Board of Supervising Engineers, Chicago (Ill.) Traction. The first installation of this class of construction included a steel tie weighing 14½ lb. per foot and 6 ft. 9 in. in length. These ties were spaced at 4-ft. intervals, and the 125-lb. rail of the Chicago section was attached to them by a special fastening. After a careful study of this type of construction under operating conditions, it was decided that the tie spacing was too great, as it brought heavier loads to the concrete foundation than it could bear. Consequently the spacing was reduced to 3 ft. After a thorough examination of this revised type of construction under service conditions, it was decided that even this interval was too great, and accordingly it was decreased. With the last reduction in the spacing, the board was confronted with the question of the cost of steel ties as compared with treated wooden ties for a given length of track. Further to convince the



Standard Construction, Capital Traction Company, Washington

board that this type of construction was wrong, rail corrugations began to develop in the extremely rigid track. To meet both of these problems wooden ties on rolled ballast were adopted to obtain resiliency, and this form of construction is being used almost exclusively in rehabilitation work at the present time.

Some engineers continue to question the advisability of using a treated tie in the place of an untreated white-oak tie, as they believe that the physical life of the untreated white-oak tie is approximately the same as the mechanical life of the treated mixed-oak or yellow-pine tie. Practically no engineers report that they have attempted to use



Types of Track Construction and Paving Used at Baltimore

treated ties again after such ties have been removed from track in reconstruction. One company in reconstructing track for paving found it necessary to remove 75,000 treated ties before it was possible to obtain the maximum life. In some localities as much as eighteen years' service has been obtained from seasoned white-oak ties. This probably more than equals the mechanical life of treated ties, unless tie plates and screw spikes are employed, which will then make the physical life determine the time of the removal of the ties from the track.

RAIL SECTIONS AND ANALYSIS

Most street railway companies in the United States have adopted the 7-in. or the grooved girder rail. Reports from thirty-one of the principal companies show that only eight are employing a 9-in. rail for track construction in paved streets. In cities where normal traffic is not dense and the rolling stock not exceptionally heavy the 7-in., 70-lb. high T-rail is favored, except where the street railway is forced to use the girder rail or is of the opinion that this rail is more satisfactory than the T-rail. In such instances the 7-in., 90-lb. grooved girder rail is being purchased largely. The extended practice of the Connecticut Company with T-rail was described at length in the issues of this paper for Aug. 30 and Sept. 6, 1913. Where the density of traffic and the weight of rolling stock increases, the 7-in., 91-lb. or 95-lb. high T-rail has been used in many cases. The weight of the 7-in. girder grooved section generally adopted varies from 100 lb. to 116 lb. per yard.

On properties where the 9-in. girder grooved rail is standard the weight of rail employed varies between 125 lb. and 141 lb. per linear yard, with the exception of one which has adopted a 9-in., 114-lb. section. Of the eight street railway companies reporting the use of the 9-in. girder rail, none is using a 9-in. T-rail. In most instances on the cross-town or suburban lines carrying a comparatively light traffic the track substructure is not changed from standard unless it is in an unpaved street, but the weight of the rail is reduced, it usually being a 7-in., 70-lb. or a 9-in., 106-lb. grooved girder.

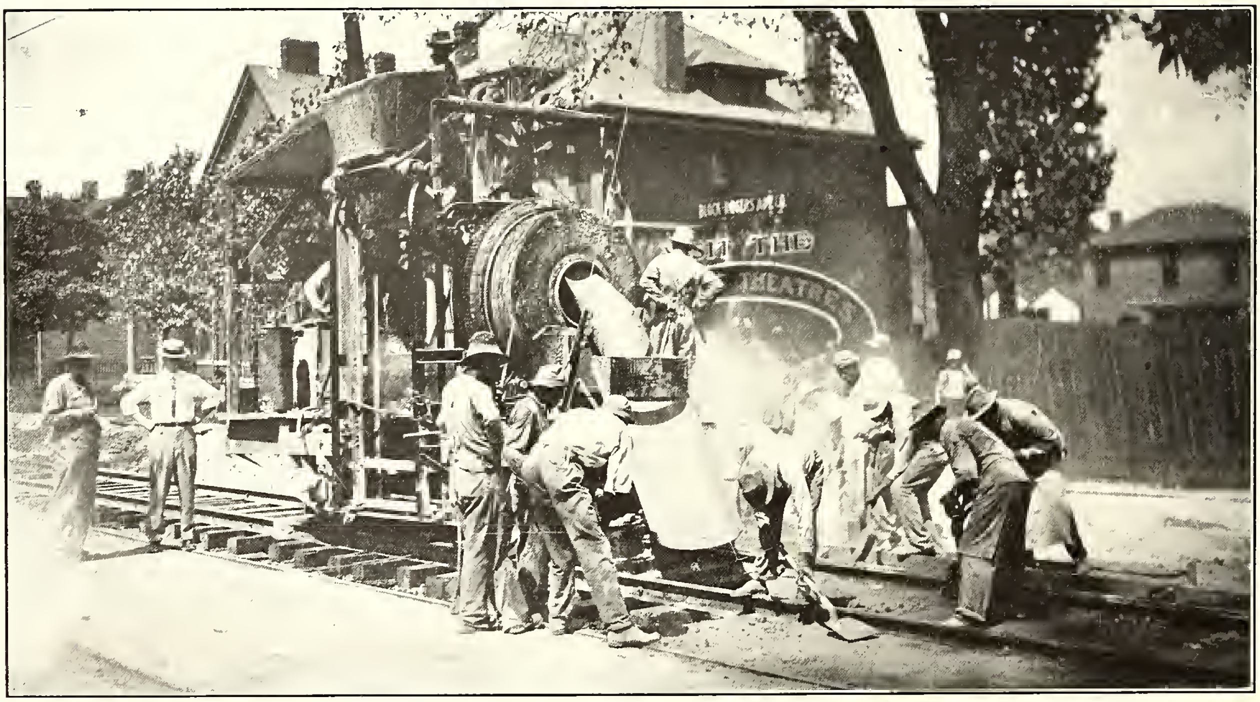
Practically all street railway companies making rail purchases specify 60-ft. to 62-ft. lengths. Thus they reduce the number of joints 50 per cent at a slight increase in the purchase price and in the cost of handling. At the present time rail manufacturers are quoting $39 per ton f.o.b. cars Chicago for girder rail in 60-ft. lengths and $37 per ton f.o.b. Chicago for girder rail in 33-ft. lengths, manufactured by the open-hearth process. Standard A.S.C.E. sections manufactured by the open-hearth process are quoted at $30 per ton f.o.b. cars Chicago for 33-ft. lengths and $32 per ton f.o.b. cars Chicago for 60-ft. lengths. To obtain the minimum price per ton, a minimum of 250 tons of girder rail or 500 tons of standard A.S.C.E. rail must be ordered.

From the foregoing figures it will be seen that an extra charge of only $2 per ton is added to the regular price when 60-ft. to 62-ft. rails are specified. The fact that the increase in price is more than offset by the reduction in the number of joints accounts for the general adoption of this length.

CHEMICAL COMPOSITION OF RAILS

Out of a total of thirty representative street railway companies in the United States, it is gratifying to note that about one-third are taking up the question of chemical composition of rail in purchases. A number are using either Class A or Class B of the American Electric Railway Engineering Association's recommended specifications, and several companies have purchased rails treated with various percentages of titanium alloy. The United Railways Company of St. Louis, Mo., has adopted a specification consisting of: carbon, 0.65 to 0.80; phosphorus, not over 0.04; silicon, 0.20; manganese, 0.60 to 0.90. This chemical composition is about half way between the Class A and Class B specifications adopted by the American Electric Railway Engineering Association, and it is being specified for all rail except guard rail in which the carbon content is from 0.60 to 0.75.

Considerable difficulty with rail corrugation recently led the United Railways Company to purchase 500 tons of T-rail treated with 10 per cent of metallic titanium. This rail was laid in 1912, and up to the present time corrugations have not appeared on it nor on the high-carbon rail which was also laid at the same time. In 1905 and 1906, however, about 40 miles of soft Bessemer steel rail was laid, and later this rail corrugated very badly. An analysis to determine the chemical composition of this rail resulted as follows: carbon, 0.55; silicon, not to exceed 0.20; phosphorus, 0.10; sulphur, 0.10; manganese, 0.80 to 1.20.



Concrete Mixer Placing Paving Foundation, Memphis Street Railway

The British Columbia Electric Railway, Vancouver, B. C., employs the chemical composition for Class A rail as adopted by the American Electric Railway Engineering Association. At heavy traffic junctions cast manganese rail has been used for the past three years with excellent success.

Other companies specifying the American Electric Railway Engineering Association's composition, either Class A or Class B, include the Memphis (Tenn.) Street Railway, the Public Service Railway of Newark, N. J., the Capital Traction Company of Washington, D. C., and the Birmingham (Ala.) Railway, Light & Power Company.

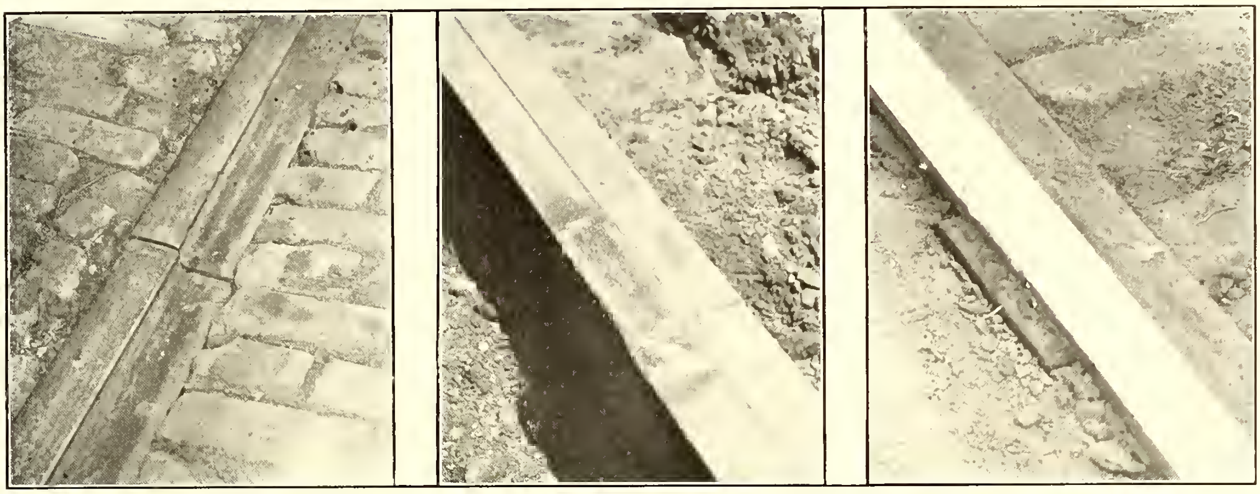
The Twin City Rapid Transit Company, Minneapolis, Minn., is specifying the following chemical composition for 7-in., 91-lb. T-rail: carbon, 0.75 to 0.90, average 0.83; sulphur, not to exceed 0.06; phosphorus, not to exceed 0.03; silicon, 0.25 to 0.40; manganese, 0.60 to 0.90. This company is purchasing rail with the high carbon and silicon content because it delays, if not entirely eliminates, rail corrugation, which developed after a short time in service when the lower carbon composition was specified.

The Metropolitan Street Railway of Kansas City, Mo., and the Cleveland (Ohio) Railway are using exclusively rail treated with one-tenth of 1 per cent metallic titanium. Both specifications are used in connection with 100-lb., 80-lb. and 70-lb. A.S.C.E. rail purchases.

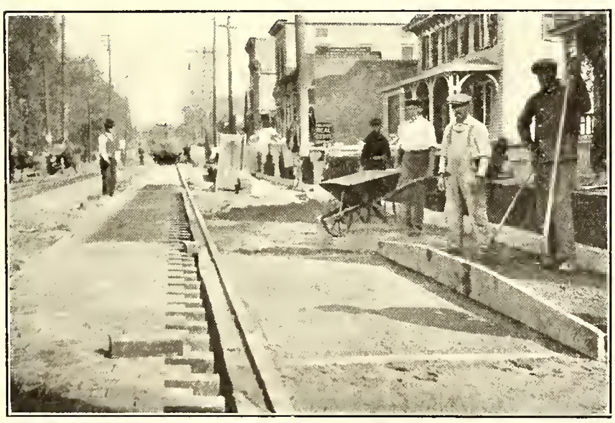
OTHER FACTORS IN RAIL LIFE

When the grooved girder rail is used the depth and self-cleaning qualities of the groove or flangeway are of prime importance if the maximum life in service is to be attained. Many grooved rail sections in use at this time are now designed so that when the allowable wear in the wheel tread is reached the flange will just about touch the bottom of the groove. In some sections there is a greater allowance for wear on the head than in the groove, or the groove is too shallow to permit the average allowable wear on wheel treads before turning. Consequently, the life of the rail is to a large extent governed by the life of the groove. When a groove becomes badly worn it ceases to be self-cleaning; the shoulders at the edge of the worn groove do not permit a solid substance, which might cause derailment, to be crowded out as the wheel flange passes along the groove.

The life of the rail is contingent on so many factors



Rail Joint Maintenance—Views Showing a Cupped Joint Before Treatment, After Restoration by Electric Welder and After Finishing by Track Grinder



Standard T-Rail Construction, Public Service Railway of New Jersey

Electrically Welded Rail Joint, Pacific Electric Railway, Los Angeles

that it is practically impossible to draw any conclusions as to what the life would be under ideal conditions. In a large measure the life of the joint is the life of the rail, but even this saying is untrue when the foundations,

Detroit United Railway—Old-Style Maintenance with Joints Cupped and Paving Disturbed

particularly at the joints, have not been properly designed or their workmanship is inferior.

Considerable attention is being given at present to reclaiming badly cupped or corrugated rail, which is either resurfaced by grinding or restored by a replacement of the worn metal by electric welding, the new metal then being ground to surface. Another method for renewing such rail is to cut off the worn portions of the ends of each rail and replace them with a short rail section which is held in place by two welded joints.

TRACK FASTENINGS

But few street railway companies have given serious consideration to the question of obtaining a longer mechanical life from ties through the use of screw spikes and tie plates. There is a wide variance of opinion as to the advisability or economy in adopting the screw spike in preference to the standard railroad spike. Some engineers hold that the additional cost is not warranted by the economies obtained, while others use them in all new construction as well as in rehabilitation work and are of the opinion that the benefits will warrant the extra expense. Local conditions have much to do with this difference of opinion, because in the case of some street railway companies the ties fail from decay before the mechanical life has been seriously affected.

The Houston Electric Company reports that it uses screw spikes in conjunction with standard spikes in all cypress ties in concrete work and exclusively whenever treated ties are used. The additional cost to install screw spikes probably has caused the lack of interest, although where they have been used they have proved entirely satisfactory. The Houston Electric Company also reports that it is next to impossible to line or gage track properly by the use of screw spikes. Whenever this work is necessary standard spikes are used to bring the rail to line and gage and a second gang follows the spikers to apply the screw spikes. This company also states

Detroit United Railway—Result of Modern Maintenance of Rail Joints by Lifting and Grinding

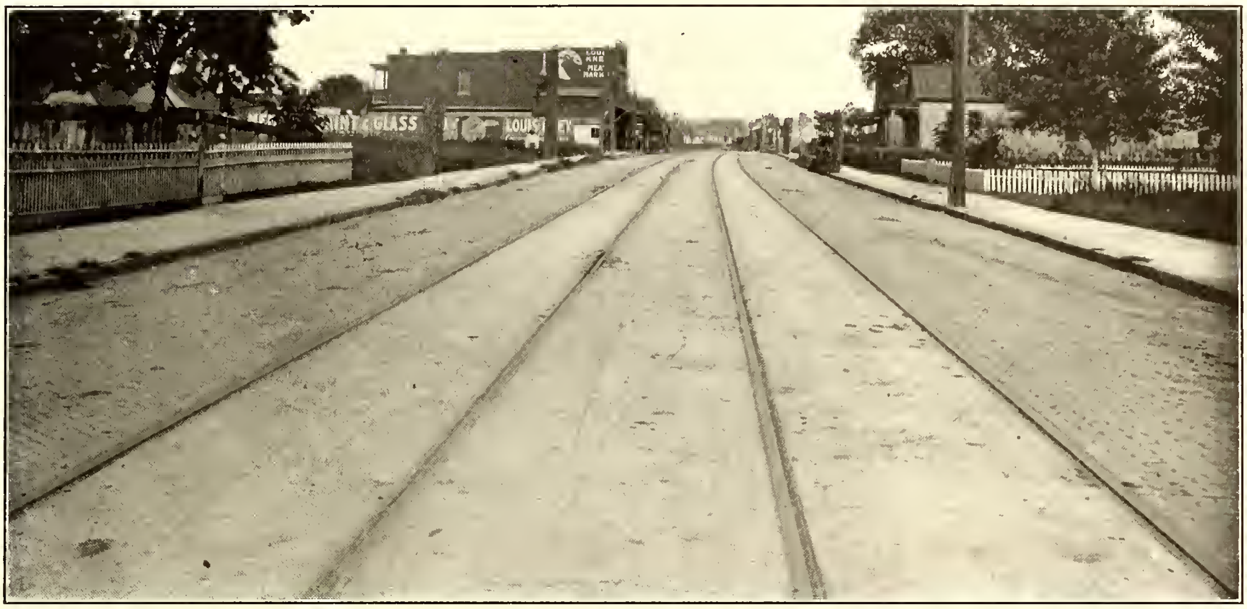
that the screw spike, as now manufactured, has a head which does not fit well over the base of the rail and that a special clip is required. The company believes there is room for considerable improvement in this particular.

The United Railways of St. Louis, Mo., uses screw

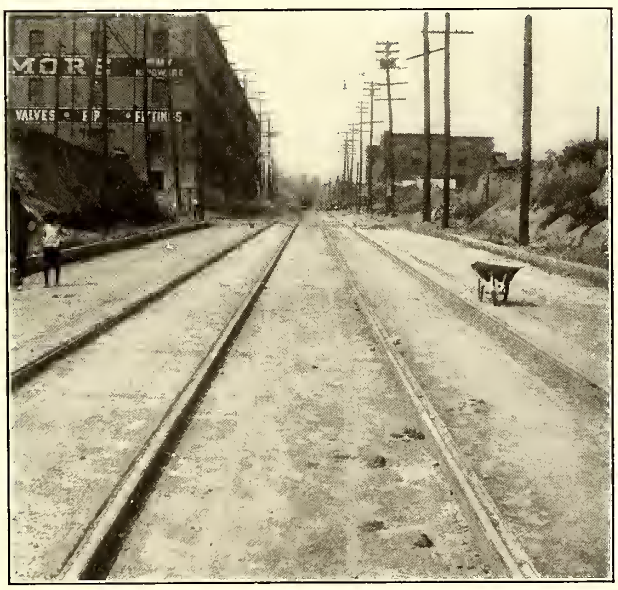
Standard Construction of Northern Texas Electric Company

spikes of special design, $7/8$ in. x 6 in. in size, for all concrete track construction. These spikes are driven with a portable electric spike-driving machine which has greatly reduced the cost of installation. Standard spikes are used in all track in unpaved streets, and in some instances where they were driven in ties in concreted track they have been found to loosen after about three or four years. In instances of this kind the standard spike is removed from the tie and replaced with the screw spike.

The British Columbia Electric Railway, of Vancouver, B. C., is seriously considering the adoption of screw spikes with a rail clip and tie plate. Its specifications will require a 300 per cent increase over the standard steam road screw spikes in the bearing area coming in contact with the base of the rail. The cross-section of the screw spike will also have to be increased, so as to provide additional strength against lateral movement in the rail. The company will also require that frictional wear be taken by the rail clip and not by the screw spike. It is believed that the adoption of the screw spike, together with the rail clip and tie plate, will tend to reduce the movement of the rail which damages the paving alongside of it.



T-Rail with Paving Protector in Concrete Paving After Five Years' Service, Memphis Street Railway



Girder-Rail Track with Tie Rods Covered Ready for Paving, Memphis Street Railway

Undoubtedly, the greatest value from the use of screw spikes would be obtained in open-track construction where trains are operated at high speed. There is some question, however, as to the advisability of employing them in street railway track construction in paved streets, particularly with hard-wood ties. Unquestionably, however, they are valuable when soft-wood ties are employed or where treated ties are used with the expectation that the maximum physical life will be obtained if mechanical life is properly protected. Screw spikes in conjunction with tie plates not only protect the tie against side shear, but the spike may be removed without injury to the tie in case it is necessary to renew the rail.

TIE PLATES AND TIE RODS

Where tie plates are employed there has been a general receding from the idea that they should be corrugated on the side coming in contact with the tie. Tests have shown that the resultant mechanical injury materially assists in bringing about tie failure. There is some question, however, as to the desirability of purchasing tie plates provided with a shoulder, particularly if the screw spike and clip are used in conjunction with it. This objection is raised because the plate may be used only with one type of rail where, if the shoulder is removed and the clip and screw spike are used, the clip may be replaced at a nominal cost to fit practically any rail provided the variation in the width of the base is not too great. Where engineers have decided on standards for track construction in paved streets and strictly adhere to them, there can be no objection to the shoulder on the tie plate. In fact, such a shoulder should be advantageous because it removes the side thrust from the screw spike to the tie plate.

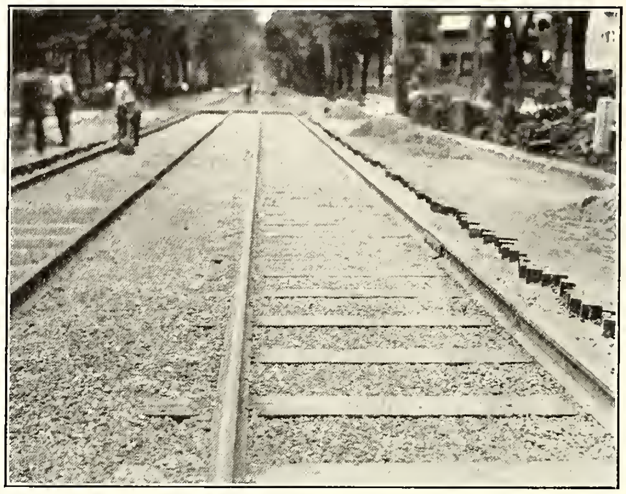
Tie rods are usually considered necessary to give the 9-in. rail stability, but some engineers doubt the advisability of using them even with the 9-in. or the 7-in. girder rail. The Cincinnati Traction Company uses a rail brace instead of a tie rod on its 9-in., 140-lb. grooved girder rail construction. This brace merely serves to prevent overturning. One spike is driven in the tie on the inside of the rail and two on the outside to prevent the rail spreading, in addition to the two spikes fixing the position of the rail brace. Several street railway companies use a round tie rod, either ¾ in. or ⅞ in. in diameter, set near the base of the rail so that it clears the surface paving material. Other companies employ a flat tie rod which varies from 3/16 to ⅜ in. in thickness with the different properties. These may be installed at the center of the web or slightly above it, and the thinness of the bar permits it to pass through the joints in the paving. With the flat rods, however, difficulty has been experienced in fitting the paving blocks between the 4-ft., 5-ft. or 6-ft. tie-rod intervals without clipping some blocks or making an exceptionally wide joint at each tie rod.

Toledo Railway—New Track Shown Resting on Concrete Foundation and After the Ballast Is Applied

The Memphis Street Railway has departed from the usual methods and employs a ⅞-in. round rod offset at each end near the web of the rail. This allows the point of application to be well above the center of the rail, and the offset in the tie rod is sufficient to permit it to pass under the paving in the concrete foundation.

RAIL JOINTS

In no department of track construction does practice follow such varied lines as in the solution of the joint problem. The fact that so many different types are being used is sufficient evidence that the problem is a pertinent one worthy of careful consideration by both engineers and manufacturers. There seems to be a general tendency, however, on the part of many of the larger companies to abandon the mechanical joint for a welded joint. Of a total of thirty street railway companies one-third already have adopted the welded joint in one form or another, and no doubt as soon as a simpler process is perfected other companies will fall in line, particularly the smaller ones where the number of joints on the system does not warrant the purchase of an expensive welding outfit. Many engineers are convinced that the welded joint produces approximately a continuous rail, and most engineers believe that a continuous rail, if possible, would greatly reduce their track maintenance as well as increase its life.



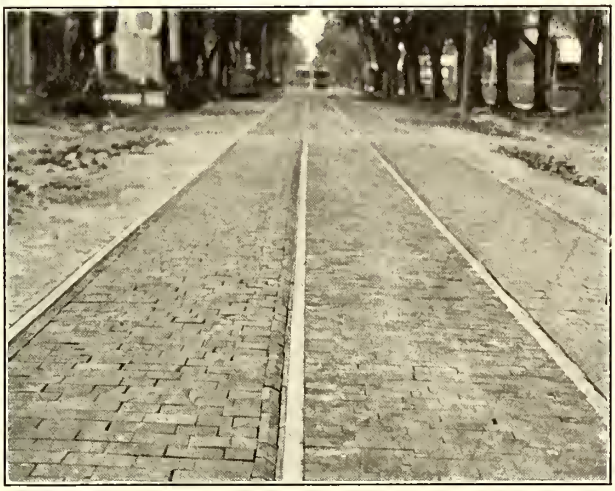
Toledo Railway—Standard Track with Ballast in Place Ready for Paving

In addition to the cast weld, thermit weld and electric weld processes, two new types of combination welded and riveted joints have been developed by the Cleveland (Ohio) Railway and the United Railways & Electric Company of Baltimore, Md. The joint designed by the Cleveland Railway is known as the Clark joint, named for Charles H. Clark, engineer maintenance of way, who invented it. This joint is a combination welded and riveted rail connection which, in addition to being welded to the rail, also is welded to the steel joint ties. The

Toledo Railway—Waterproofing Coat of Concrete Laid on Ballast

Baltimore joint differs from the Clark joint only in a few particulars.

The 26-in. six-bolt continuous joint appears to be the most popular mechanical joint. Some engineers have held to the 26-in. length but have increased the number of bolts or the size of them from ⅞ in. to 1 in. The Philadelphia Rapid Transit Company and the United Railways of St. Louis are now using the Nichols joint in their latest type of track construction. The Nichols joint is a form of riveted continuous joint which does not fit close under the head of the rail or around the base, and the open space is filled with molten spelter after the joint is applied to the rail.



Toledo Railway—View Showing Pavement Before Filling with Sand

Toledo Railway—View Showing Completed Track and Paving

SPECIAL WORK

Recently there has been a decided tendency on the part of engineers to confine their special work purchases to two distinct types, each serving a particular purpose. Solid manganese switches and mates are being purchased quite generally, instead of the insert type. On the other hand, a number of street railways, after considerable experience with solid manganese in frogs and crossings where the angle was in excess of 11 deg., have returned to the renewable insert type as standard. Although there has been more or less complaint from engineers regarding the failure of inserts to remain tight under heavy traffic, no serious difficulty has been experienced in re-tightening them. In most instances crossings fail under impact at the intersection of the flangeways before any other repairs are necessary. If the renewable feature, characteristic of the insert type, should be abandoned, the entire crossing necessarily would have to be removed in case trouble developed at the intersection of the flangeways. No doubt many engineers are aware of the fact that solid manganese crossings and frogs of unusual angles are considerably more expensive than standard pieces such as switches and mates. The increased cost is due to the fact that a special pattern and crossing must be made for each order. The saving effected by using the insert type of special work is quite an item, as is also the renewable feature of the insert, from a track maintenance standpoint.

Toledo Railway—Laying Creosote Paving Block on Sand Cushion

The British Columbia Electric Railway, Vancouver, B. C., has adopted solid manganese switches, mates, frogs and crossings for all work where the traffic exceeds 1000 tons per hour. Since solid manganese was adopted, six years ago, this company has installed a number of pieces, one being at an intersection carrying approximately 5010 tons per hour, and not over $500 has been spent in renewals.

The Connecticut Company purchases practically all hard-center special work and solid manganese only to a limited extent for steam railroad crossings. The built-up type of special work is used in storage yards and in open-track construction.

Difficulties experienced in special-work maintenance by the Milwaukee Electric Railway & Light Company include loosened hard centers and broken as well as loose wing rails in the solid castings. It appears that these failures have been attributed to faulty foundations as well as bad drainage and not to the special work. This company has endeavored to overcome these difficulties by the use of well-drained crushed-stone ballast thoroughly rolled and tamped under each piece and by fastening the special work down upon hard-wood ties with 7/8-in. screw spikes.

The Metropolitan Street Railway Company, Kansas City, Mo., has had considerable trouble with the cast-bound frogs and crossings, but has partially remedied these troubles by the adoption of the cast-steel type of construction. In many instances it has been necessary to remove the cast-bound work because it had broken or failed otherwise. Twelve years' experience with cast steel has been that when its removal was required it was not on account of failure by breaking, but because the flangeways and rail were badly worn at the intersections.

Concrete Paving with T-Rail, Birmingham Railway Light & Power Company

The Metropolitan Street Railway's most serious difficulty in maintaining special work has been caused by broken inserts and paving failures around special work, due to the impact blows of wheels passing over crossing frogs. Presumably these pieces of special work were manufactured for flange bearing, but in order to take the bearing at the intersection the wheel strikes a very heavy blow. This trouble has been removed in recent special work purchases by an increased length of the insert plates and the provision of a gentle incline to a shallow flange bearing. In this type the wheel flange takes the bearing with a slight angle of impact and the tread is raised clear of the ball of the rail, with the result that the impact blow has been eliminated. This type of construction is used in both crossings and frogs, and the expectation is that it will obviate numerous other difficulties and greatly reduce the cost of maintenance.

Bonds in track construction in paved streets are necessarily confined to types that can be applied under the single bar. This requires a type of compressed terminal or brazed bond unless the rail has been made continuous by the use of the electric weld, thermit weld or other types of welded joints. As a rule, the rail is bought punched to take one or two compressed terminal bonds so that it is necessary only to ream out the holes. Both water and oil are used as lubricants, but if the latter is employed the hole must be swabbed with alcohol. In some instances, where the traffic is dense and additional conductivity is required in the return circuits, copper cables are laid in the sand cushion under the paving with frequent connections to the rails.

PAVING

Paving is a subject which has been under much discussion and experimentation, and as yet few engineers agree as to what is the best method and what are the best materials to use in the track allowance. In a number of cities the type of paving employed is specified by the city's engineer, but in many instances the street railway company's engineer has presented such a convincing argument that he has been permitted to pave the track allowance in the way he deems best.

An examination of the different designs of track in paved streets in the accompanying illustrations shows that there are almost as many methods of laying the paving as there are types of construction employed. Owing to the diversified character of paving materials employed, few general rules may be drawn. Usually the paving surface is laid over a sand cushion on a solid concrete foundation and the irregular rail section is squared up in most instances with a cement mortar. Some companies, however, lay the paving and fill the interstices around the rail with sand or asphaltum or any other filler used in the paving.

Many engineers are of the opinion that granite rock used either with T-rail or grooved girder rail is the best material to employ in the track allowance when vehicular traffic is heavy. In the residential section, where light traffic predominates, the paving material should be brick with a special stretcher and filler for T-rail or else wood block.

The question of waterproofing the paving surface is an important one and has received careful study. Asphaltum filler is used with all types of paving to accomplish this, but in a great many instances cement grout receives preference. Arguments favoring the latter filler are that it is not only impervious to water but is as hard as the paving. This quality protects the edges of brick, wood or granite block and results in longer life and a smoother pavement. Most of the street railway companies using granite block where vehicular traffic is heavy also use it to a limited extent in residential or light vehicular traffic sections. The usual method is to lay a header course along the flangeway and a stretcher course along the outside of the rail. The rest of the paving conforms to that specified by the city.

Recent experiments with a solid concrete paving surface in the track allowance have been quite successful, and the cost of paving this strip has been materially reduced. This paving surface is applied at the same time that the foundation is put in place and does not require a special class of laborers to do the work. The fact that the concrete gang can complete the paving not only results in economy in material and labor but also expedites the completion of the work.

Creosoted wood block is gaining in favor as a paving material in the track allowance, both for heavy and light vehicular traffic. Some engineers, however, have met with difficulty because they failed to provide sufficiently wide expansion joints. Consequently during periods of high temperature the paving has buckled. This has been overcome, however, by an increase in the space allowed for expansion, and some street railways allow as much as 3/4 in. between the rails in standard-gage track.

One objection to both brick and creosoted wood block as compared with granite block is that much of it is broken when it is necessary to make repairs. Hence a larger percentage of new material is used than is required when similar repairs are made in granite block pavement. To offset this advantage in granite, other engineers claim that the fact that wood block may be cut to fit around special work is worthy of consideration.

A common form of pavement failure encountered in the Northern States is from upheavals during periods of low temperature. No doubt this is due to flaws or leaks in the filler or the paving surface which permit water to reach the sand cushion. Several engineers, in coping with this difficulty, have replaced the old sand cushion with a sand-cement mortar. This is laid in place comparatively dry and formed to the paving contour with a templet. After the mortar has set around the paving block and the filler has been applied, the paving is absolutely impervious to water. No special trouble has been found when repairs are made to pavement of this character, first, because the number of repairs is reduced and, second, because the bond between the paving block and the concrete is not so great as to make it difficult to separate them.

Other usual forms of paving failures are found at the joints and are due to the impact blow, which causes a slight movement in the rail. It appears that the only way to overcome this difficulty is to adopt a joint which will make the rail as nearly continuous as possible and thus remove the cause of this trouble.

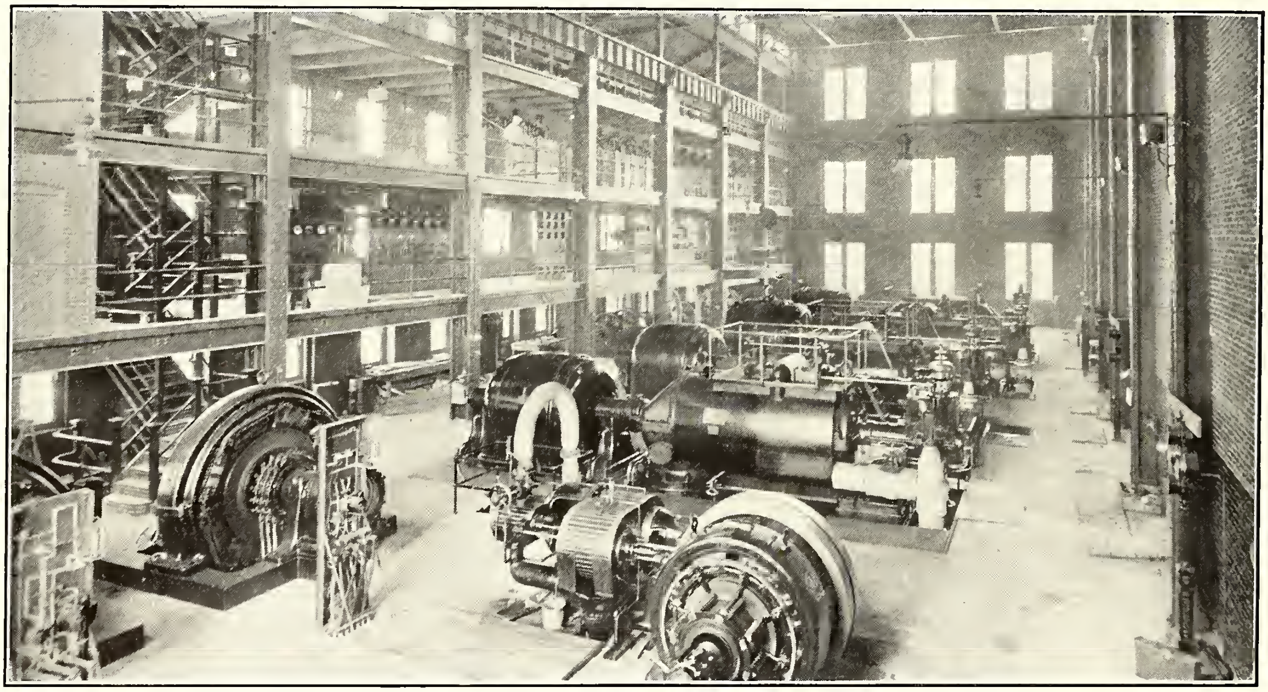
Laying Granite Block Paving on Mortar Bed, United Railroads of San Francisco

POWER GENERATION AND TRANSMISSION

TWENTY years ago mechanical and electrical engineers looked upon electric power generation and distribution as in their infancy and subject to very great improvement. If they ventured to think two decades ahead, they must have expected that standardization would be accomplished by that time. Yet never in the history of the industry were more important and radical changes being made than at present. Hardly had the Corliss engine been perfected than the steam turbine arose to displace it, and to-day some of the finest examples of this type of engine in first-class condition are a "drug on the market."

In the electrical field, by the time that the problems of d.c. commutation had been solved, the d.c. generator was forced from the power house by the alternator, which was so much better adapted for steam-turbine driving. Even before this, however, the necessity for high-voltage transmission had virtually brought about the same change. In the alternator itself the endeavor of designers was at first to produce good inherent regulation of voltage. As soon as this was accomplished it was found after all not to be what was wanted on account of the serious effects of short-circuit.

A few years ago small generating units were used, partly because the problems connected with the design of large ones had not been solved, partly on account of the desire of operators to keep the connected generator capacity carefully adjusted to the load, partly to insure high efficiency and partly to prevent the danger of great reduction in capacity when a break-down occurred. Now the tendency is toward larger and larger units to obtain the benefit of their lower steam consumption and lower first cost, and as large units are made to yield high efficiency over a wide range of load there is not the same need as formerly for careful attention to loading.



Turbine Room in Georgetown Power Station, Capital Traction Company

Although in the engine room radical changes have been effected, there was for a long time little progress in the boiler room. Boiler units gave efficiencies satisfactory for the period and, as far as the construction of the boilers themselves was concerned, the practice was fairly well standardized. Now, however, all of this is changing rapidly, for the use of large turbo-generators resulted finally in enormous power-generating density, as shown by small area of floor space per kilowatt, and this emphasized the disparity between turbine and boiler room sizes. The result has been a tendency to equalize these by an increase in capacity of boiler units—to a slight extent by increasing the heating surface but to a greater one by the use of forced draft, superheaters and economizers. At the present rate of progress it will not be long before the boiler room will have resumed its normal proportionate size and three times as much steam per square foot of floor area as formerly will be generated in standard practice.

In the field of electrical transmission and distribution the same conditions appear. The increasing use of central-station power for railway purposes and the corresponding widening of the area of distribution have necessitated the use of voltages which a few years ago were considered almost impracticable. Corresponding to this has necessarily come radical change in design of insulators, towers, transformers and auxiliaries. Protection from lightning at these high voltages was indeed the bugbear of the transmission engineer until the comparatively recent advent of the electrolytic arrester relieved him of much anxiety.

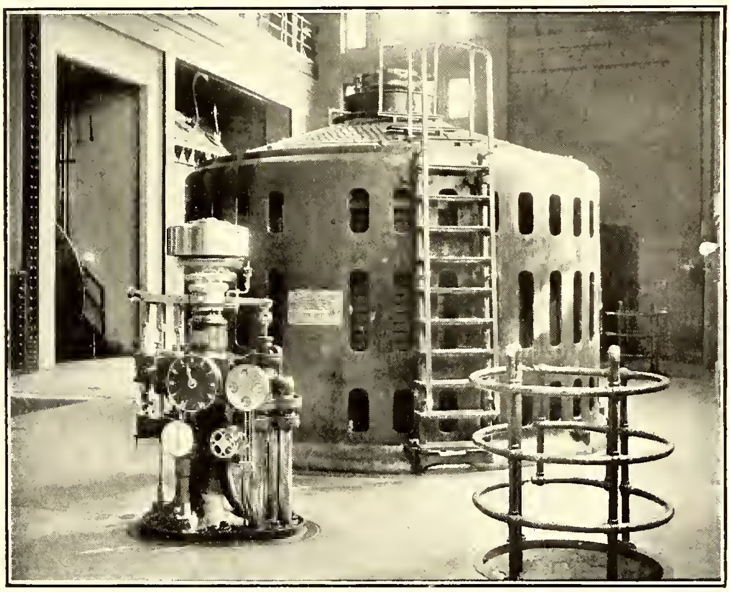
In the substation the same law of increase was followed by the rotary converter until the units became very bulky. The practical application of the commutating pole to them as well as to generators is now, however, resulting in the use of increased speed; and this, combined with improved ventilation and better materials, has brought down the size of the rotary in a remarkable manner. The commutating pole has also made possible the use of 60-cycle current with large rotaries and hence has made easier the combination of railway and central-station loads.

While the above-mentioned changes and many more have been taking place and power generation has become more and more complicated there has developed a movement in the direction of throwing over this highly specialized engineering end of the business and purchasing energy from specialists in that line. In an increasing number of localities this can be done to advantage. Primarily the business of a railway is transportation, and the manufacture of electrical energy is no more a direct part of this business than the manufacture of cars, a field in which the railways have hardly ever been able to compete successfully. During the early days of electric railways most of them were operated as parts of a general business which included electric lighting and, later on, the furnishing of industrial power. The production of electricity was, in fact, the main part and the operation of cars a subsidiary part of the business. However, with the general development of the use of electricity and the standardization of the methods of producing it, in addition to the enormous growth of the street railway systems in the larger cities, the positions of the two parts of the business have been reversed. Owing to the opportunities for economy possessed by the specialist in any industry it has been found that electric power may in many instances be profitably sold by a power company at a price which is lower than the cost of production by a street railway.

THE BOILER PLANT

In the past the inherent efficiency of the boiler equipment has been less than a reasonable value, owing often to imperfect adaptation to the available fuel and water supply. Quite recently, however, the boiler room has been receiving more careful study, as is evidenced by the many changes made and being made in the design of boilers, grates and superheaters and by the introduction of all sorts of auxiliaries.

The agitation for smokeless power plants also has furnished an incentive for the study of more perfect combustion. It has, in addition to the desire for more efficient boilers, led to changes in the arrangement of combustion chambers, fire arches, baffling and other boiler elements, and has assisted in popularizing automatic stokers, automatic flue dampers and the like.



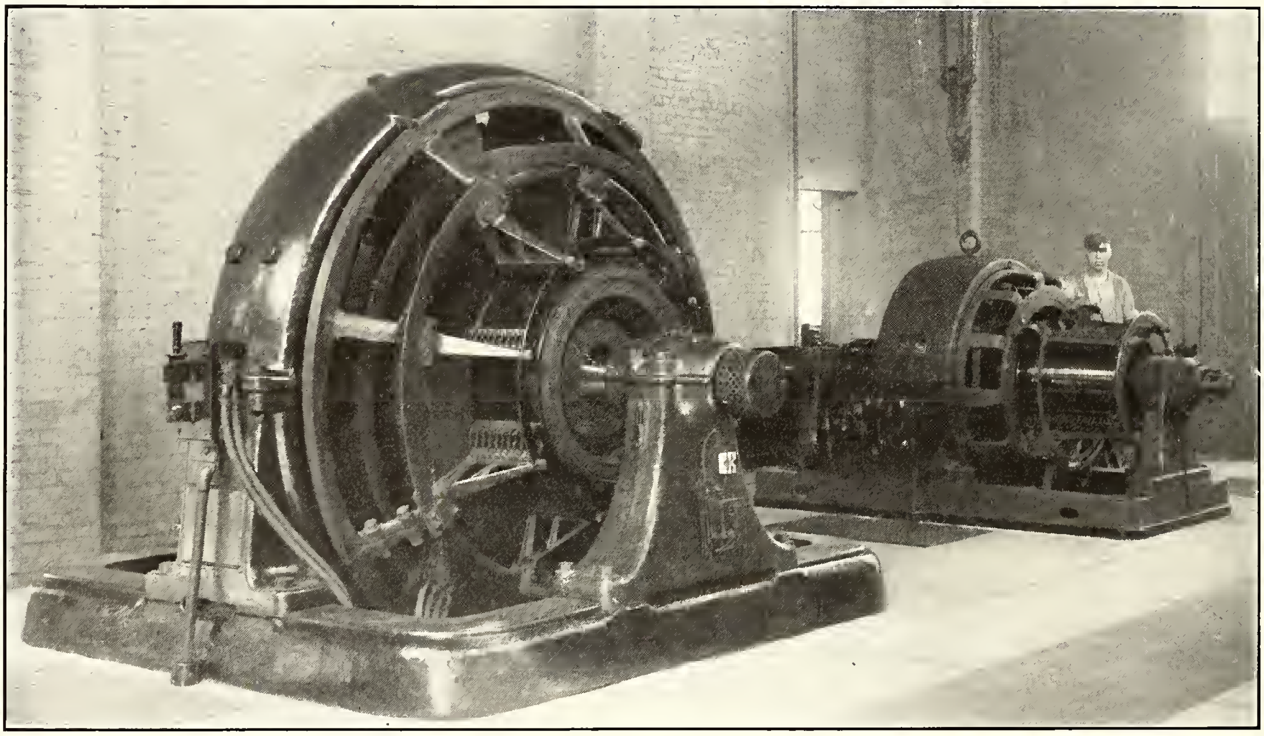
Views of 10,000-kw Generator and of Interior of Las Plumas Hydroelectric Station, Great Western Power Company

BOILER RATING

The irrational method used for rating boilers in horse-power has long been a source of irritation to power plant engineers. When the present unit was chosen a boiler horse-power represented approximately the rate at which steam was required to develop a brake horse-power at the engine. As engine performance was improved this condition no longer held. In fact, one boiler horse-power can now be made to produce more than three brake horse-powers, and boilers are to-day actually rated in terms of heating surface, although nominally the rating is still specified in horse-power, most builders using about 10 sq. ft. as a unit.

That this nominal rating is absurd is evidenced by the ability of any good boiler to deliver at least twice its rating with high efficiency. In recent tests by the Narragansett Electric Light Company, a boiler was operated for eight hours at 250 per cent of rating and with an equivalent evaporation of 10.51 lb. of water per pound of combustible. In this case the firing was excellent, as shown by the presence of 16 per cent of CO_2 in the flue gases. Tests made by the Union Light & Power Company of St. Louis show that its boilers also can be forced to 250 per cent of rating without difficulty, and several recent specifications call for ability to operate at over twice the rated capacity.

There is, however, a demand for a heat output rating and the technical societies concerned have approved the suggestion of a new unit of heat power, the myriawatt. This, it is hoped, will be accepted in place of the old boiler horse-power, to which it is nearly equal, the horse-power being the equivalent of 33,479 b.t.u. per hour, and the myriawatt of 34,150 b.t.u. per hour, so that a boiler of 1000 myriawatts capacity might still have about 10,000 sq. ft. of heating surface. The advantages claimed for this unit of heat power are the simplification and interchangeability of electrical, mechanical and thermal terms.



View Showing Relative Sizes of Old and New Rotary Converters of 1000-kw Capacity, One 375-r.p.m. without Interpoles and the Other 750-r.p.m. with Interpoles

INCREASING BOILER CAPACITY

Since the use of forced draft and automatic stokers has made it possible to operate boilers at loads much above the rating and with only slightly reduced efficiency, this provides for peak loads without excessive reserve equipment. In large boilers the use of grates at both ends has been very successful, and when this arrangement is impracticable oil burners can be used to supplement the coal grates. While the oil costs more than coal its use is justified by the saving in first cost of equipment. The Consolidated Gas & Electric Company of Baltimore found that a boiler giving 1188 hp with coal gave 702 hp with oil alone and 1445 hp with oil and coal. In this case the oil burners were at the rear of the boiler. The forcing of boilers has no detrimental effect on the tubes, as the rapid circulation of water is really beneficial. The wear and tear on the brickwork is increased, but this is not serious.

The size of boiler unit is not, however, changing to correspond with that of the turbine. The latter is being used in as large units as the load on the station will permit, and in some extreme cases a single unit comprises the entire turbine equipment. Just what has delayed the progress of the boiler is not evident, especially in view of the very satisfactory results obtained with the 2500-hp boilers at Detroit. A unit with about 6000 sq. ft. heating surface still seems to be the most popular.

The 4-in. tube has been standard in large water-tube boilers for many years, but good results can undoubtedly be secured by using smaller tubes. In fact, experiments conducted recently by the Interborough Rapid Transit Company with small tubes placed in the upper rows of a horizontal tubular boiler produced satisfactory results, although on account of the expense the existing boilers will not be so equipped.

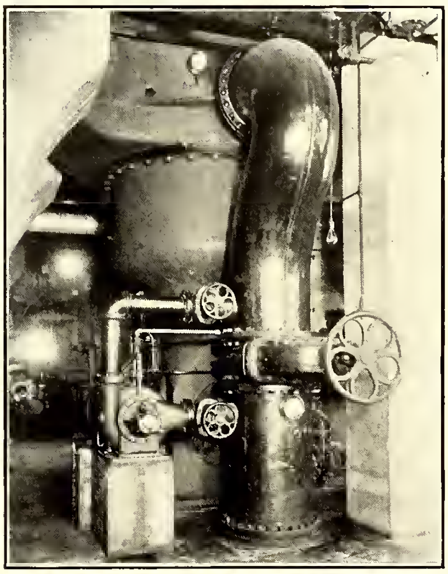
The enforced use of superheaters with boilers for turbine installations has resulted in a considerable increase in the capacity of the boilers, and experience has settled upon a superheater forming part of the boiler as superior to the separately fired type.

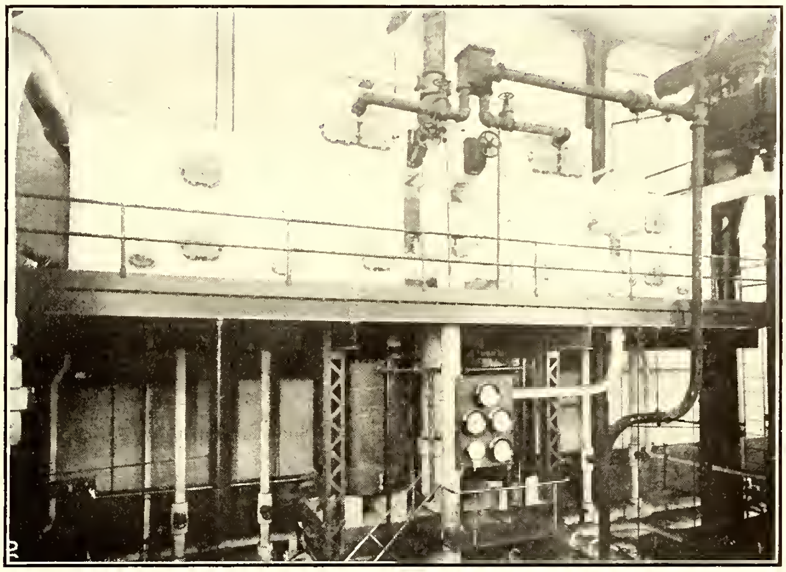
STOKERS AND PRESSURE REGULATORS

The use of automatic stokers even in small plants is practically general. The possibility of the use of automatic control of draft and fire supply in connection with them to meet varying load demands is a logical step toward the reduction of the cost of boiler room labor.

Further, as the output and efficiency of the boiler room depend so much upon the enlightened interest of the firemen, it pays to reduce the amount of manual labor required of them. The newer railway boiler plants of a capacity in excess of 2000 hp are, in general, provided with one or more types of the several satisfactory available machines. On account of the differences in load requirements and in fuel characteristics, each stoker installation presents its own problems and there is no one general solution of them.

For bituminous slack the chain grate has become very popular, as it is simple and can be operated continuously. It is now being successfully adapted for use with coking coals. In the new plant of the Cleveland Illuminating Company an illustration of this is furnished. At the front of the furnace is an inclined agitating fire plate of two leaves, the lower one resting upon the grate. To these leaves a reciprocating motion is given, and as the coal flows over them the large lumps of coke are broken up. The grates have an average travel of 10 ft. per minute. They burn from 20 lb. to 40 lb. of coal per square foot of grate per hour and have reached a maximum rate of 65 lb.





By-Pass Priming Pump on Jet Condenser—Twin Feed-Water Heater of the Open Type with Meter

The underfeed stoker now appears to be making rapid progress. As it is better adapted to forcing than the chain grate, a combination of the two types in a boiler room would have certain advantages, the underfeed stokers being brought in for peak loads. In many of the larger plants more than one type of stoker is in use, as the present development is so rapid that constant experimenting is necessary to keep pace with it.

Closely related to the automatic stoker is the automatic pressure regulator, because rapid forcing of the furnace makes it difficult for the attendant to manipulate his fires, especially when the load is fluctuating. There is a proper prejudice against automatic apparatus on account of its complexity and of the danger that, relieved from direct responsibility, the attendant will neglect his duties. This objection is probably valid in the case of automatic feed-water regulators, but does not hold in the case of pressure regulation.

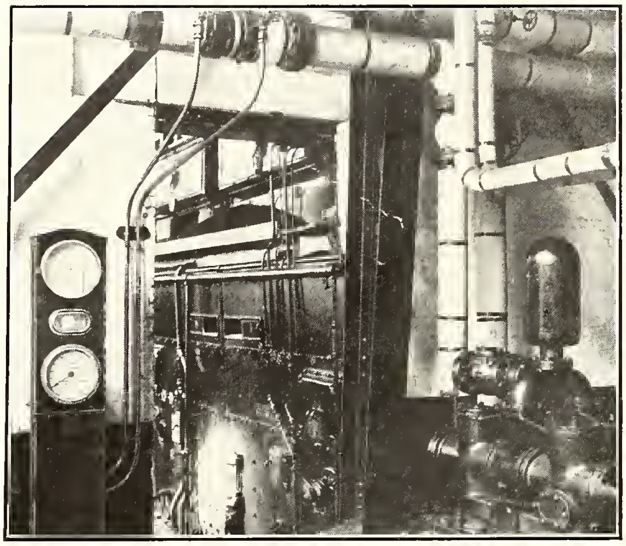
FEATURES OF BOILER OPERATION

An inspection of recent boiler rooms impresses one with the increasing attention being given to measurements of various kinds. Coal-weighing hoppers, Venturi and other types of water meters, steam-flow meters, CO_2 recorders, recording pressure gages, draft gages and the like are the order of the day. This is a sign of the appreciation of a principle which has long been useful in the engine room, namely, that better service can be secured when the operators can see the results of their efforts. In the engine room these results are more evident and the quantities involved are more easily measured. Users of CO_2 apparatus testify to an increase in output due to careful watching of the flue gas composition, as a high percentage of CO_2 can always be secured with intelligent handling of fuel and draft.

These measurements are useful only as they lead to increased care. To encourage this some incentive may well be given, such, for example, as the bonus provided for the boiler room attendants by the Des Moines Electric Company. This company increases by 1 per cent the wages of all boiler room employees for each 0.1 lb. of coal per kw-hr. saved during a month. The standard for each month is set by the chief engineer. The St. Joseph Railway, Light, Heat & Power Company encourages careful operation by a system of water meters in the boiler-feed lines, the make-up supply pipe and the return lines from the turbine and engine units. All devices of this kind, whether reinforced with pecuniary rewards or not, instil pride in good performance and tend to develop skilful operators.

ECONOMIZERS AND FEED-WATER HEATERS

The use of forced draft has brought into prominence the advantages of the economizer, which was formerly looked upon somewhat as a luxury and an unnecessary refinement. With the former conservative boiler practice the flue-gas temperature could be kept down to a reasonable value, but with forced draft, even with liberal superheater surface, the flue-gas temperature is bound to increase. In consequence, the old nominal heating surface rating of boilers must in future be made to include the



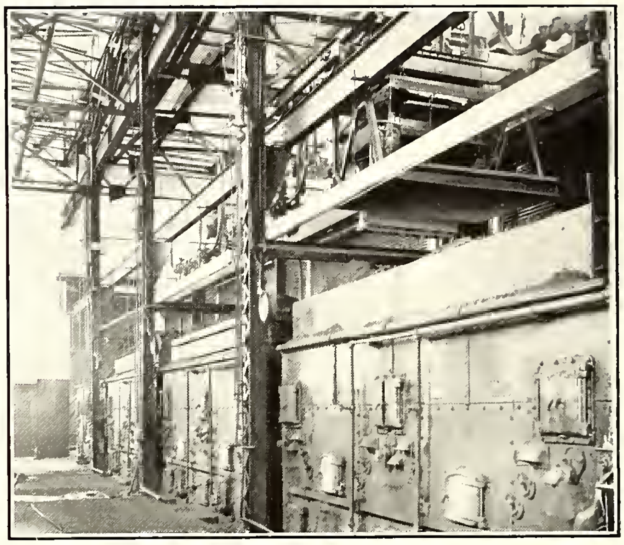
Recording Venturi Meter in 6-in. Boiler Feed-Water Line

auxiliary heating surface as well. It has been suggested that the following is a fair division of surface for a nominal boiler horse-power: boiler surface, 4½ sq. ft.; superheater surface, 1½ sq. ft.; economizer surface, 6 sq. ft. With this arrangement the gases should leave the boiler at about 800 deg. Fahr. and the superheater at 700 deg. The economizer should remove, say, 400 deg., leaving the flue-gas temperature at 300 deg. This arrangement will yield about 100 deg. superheat as required in American practice.

A recent development in feed-water heaters during the past year has been the application of the water-metering principle to the feed-water heater when it is of the "open" type. One well-known manufacturer has developed a simple measuring box which is separated into two parts by a partition in which is a V-notch weir. By means of the height of water in the notch the flow of water is recorded on a dial mechanism. Thus an accurate record of the water fed to the boilers is easily made. Installations of this kind are now being made by the Rochester Railway & Light Company and the Kansas City Terminal Company.

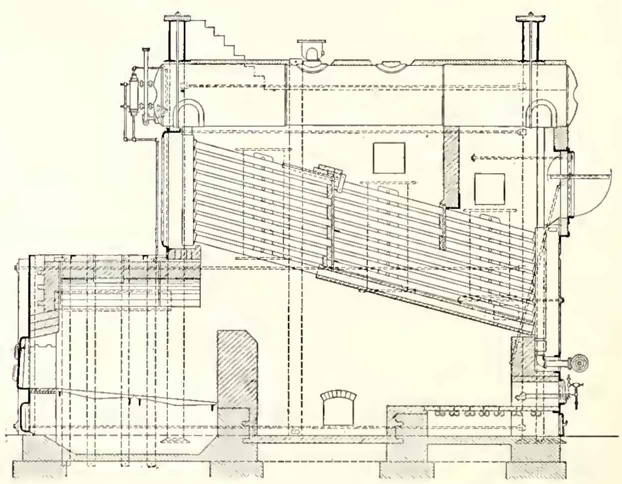
COAL STORAGE AND TRANSFORMATION

The coal-handling equipment is probably the part of the power plant in which most individuality and originality can be displayed to-day. The coal supply is so vital that ample storage must be provided, but for economy of handling the routine supply must be delivered as directly as possible from the cars to the boiler bunkers. The arguments in favor of automatic stokers can be extended to conveying apparatus, for a plant large enough to use one economically can afford the other. H. J. Edsall recently described a case in which unusual facilities were afforded for comparing the cost of hand and mechanical transportation of coal. Two boiler rooms in the same plant had similar equipments of sixteen 260-hp boilers and in each case twelve were in service. One section had coal delivered direct from cars on the firing-aisle floor between two rows of boilers facing each other. An elec-



Traveling Coal Hopper Over Murphy Stokers, Worcester & Blackstone Valley Railway

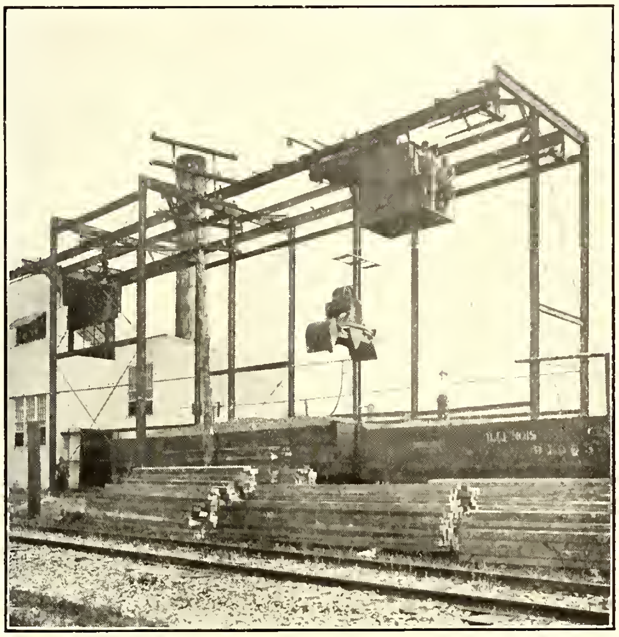
tric telpher was used in removing ashes. The second section had crusher, elevator, coal conveyor, overhead bins and ash conveyor. The first section burned 1092 tons of coal per week at a cost for labor and energy of $625, while the second section burned 1260 tons at a cost of $445. The saving was sufficient to pay for the conveying machinery in five years and to yield a net



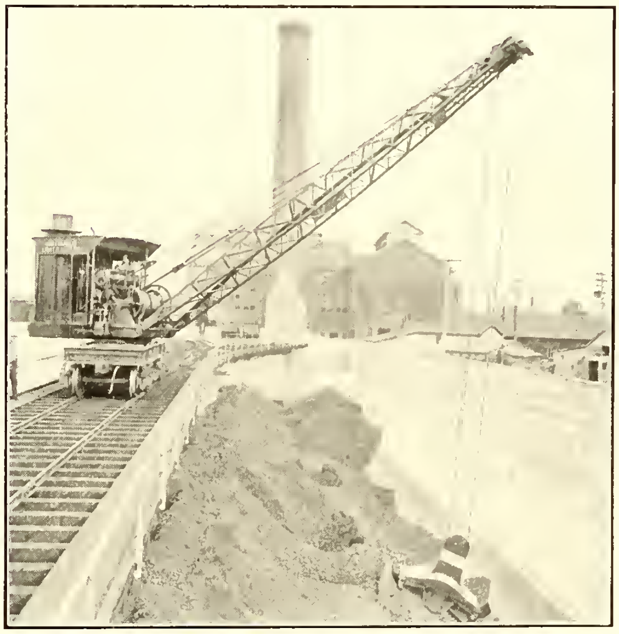
Boiler with Wood-Burning Furnace at Front and Oil Burner at Rear, Portland Railway

saving of several thousand dollars per annum thereafter.

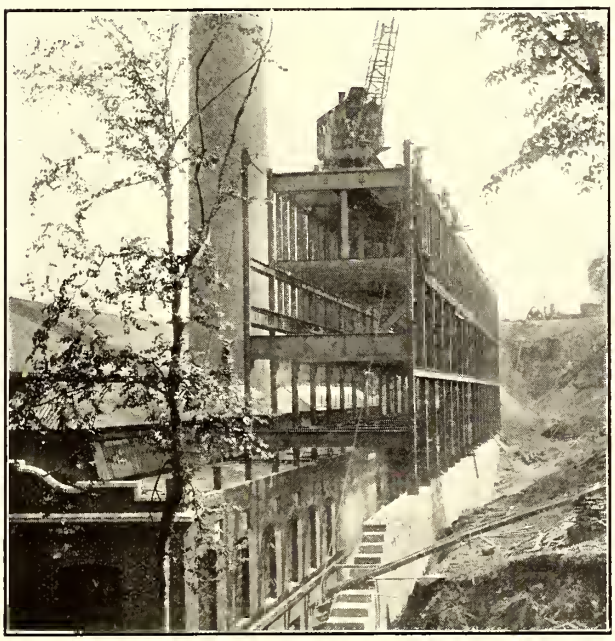
The most economical manner of delivering coal to the boilers is some form of gravity feed even if the firing is to be done by hand. If ground area is expensive, bunkers over the boilers or the firing aisles are usually employed. These can be filled by small cars or belt or bucket conveyors. The capacity should be at least a day's supply. These deliver the coal through spouts to the stoker hoppers or to piles on the floor for hand firing. A cheaper plan and one which is convenient for weighing purposes is the use of a traveling bunker or "larry" from which the coal is spouted to the hoppers one at a time. When there is room and the firing aisle is against an outside wall the bunkers can be outside of the boiler room and the coal spouted through the wall. This construction is cheap both because a less expensive bunker can be used and because less headroom over the boilers is required. In view of the variety in coal-handling practice it is impossible to make general statements. A few familiar examples will serve, however, to recall to mind some recent installations.



Handling Coal Direct from Cars with Trolley and Grab Bucket



Handling Coal from Storage Pit with Locomotive Crane and 2-yd. Grab Bucket



Coal Trestle Built Over Boiler Room, George Power Station, Northern Ohio Traction

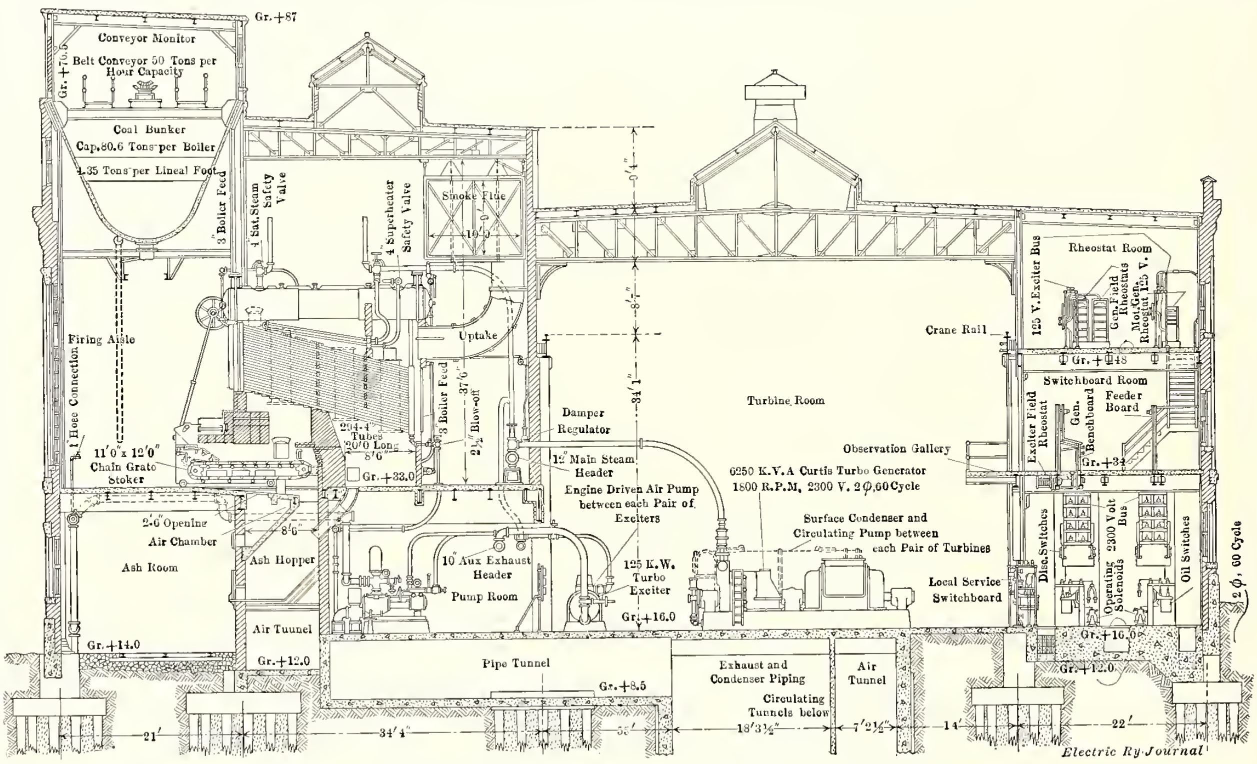
One of the simplest boiler plant plans is that used by the Southern Power Company in its steam relay stations. In this there is a concrete trestle located outside the boiler room wall and covering a storage space 25 ft. wide. The coal flows through openings in the wall, forming piles from which it is shoveled into the hoppers. In addition, there is a track in front of the boiler and around the storage space on which flat firing cars can be run for use when the fuel pile is low. In the Des Moines plant there is a traveling hopper for each of the four 400-hp boilers, moving on overhead rails placed perpendicular to the line of the boilers. A storage pit over which coal cars can be run occupies a space at one side of the boiler room. Close to this is a traveling crane and grab bucket by means of which the hoppers are filled either from the cars direct or from the pit. The Lexington Traction & Terminal Company's boiler room has a 700-ton storage pit with track above. From this a crane with grab bucket serves the hoppers either direct or through the crusher. The operation of charging the hoppers of four 500-hp stokers requires but twenty minutes. The Cleveland, Painesville & Eastern Railroad Company's plant is located in a depression close beside a trestle over which one of its lines runs. In this trestle a 500-ton parabolic-bottom, concrete hopper has been built. Beside it is an auxiliary track for small push cars which convey the coal direct into the stoker hoppers. In the Hoosac Tunnel plant of the New Haven Railroad a receiving track hopper is connected with an elevated storage bin by a bucket conveyor, coal being crushed before it is dropped into the bin, which is at one end of the boiler room.

From this a weighing larry delivers it to the stoker hoppers. In the Public Service Electric Company's Perth Amboy plant a 400-ft. belt conveyor in a runway leads from a wharf to a 1500-ton concrete coal bunker above the boilers. Spouts fitted with weighing devices connect this with the hoppers. Each 1600-lb. charge is tallied on a registering clock.

The above plants are all of small or moderate sizes. In larger ones the labor item is proportionately reduced by greater investments in machinery. For example, the Cleveland Illuminating Company, which supplies power to the Cleveland Railway Company, has an elaborate coal plant. A storage yard of 23,000 tons capacity contains an unloading trough 540 ft. long. The yard is served by an electrically driven gantry crane with a 2-ton clamshell bucket. When coal is to be used directly boiler floor and is unloaded either by dumping into hoppers direct or by means of a clamshell-bucket crane. These hoppers discharge into the crushers below. The conveyor is electrically driven and is made up of 36-in. by 36-in. buckets.

DISPOSAL OF ASHES

The illustrations indicate the great variety of equipment used in coal handling. The problem of removing ashes is much simpler and the solutions are more uniform. The ash hoppers below standard stokers are very much alike and all can be adapted to discharge into small hand-operated cars on industrial railway tracks. These are located on the floors below the boiler rooms or in tunnels specially constructed for them. The abrasive action of the ashes is such that cars give better results than conveyors, and as the weight of ashes to be handled



Cross-Section of Savannah Power Company's Riverside Power Station

it is loaded on hopper-bottom cars and, after being weighed on track scales, is crushed and picked up by an inclined belt conveyor. Over the boilers are concrete-lined bunkers of 1000 tons capacity for a single row of boilers and 2000 tons for a double row of boilers, equivalent to 100 tons per boiler, or five days' supply. These bunkers are fed from a distributing belt conveyor connecting with the inclined one. From the bunkers the coal falls into 5-ton weighing hoppers and then is delivered to the spreader chutes. In the Commonwealth Edison Northwest station boiler room, described in last year's convention issue, each unit of twenty boilers is supplied through a conveyor forming a rectangle of which the vertical sides are 104 ft. high and the horizontal sides 120 ft. long. The lower horizontal stretch is in a tunnel in which is a movable crusher mounted on rails. The coal is brought in cars into a large receiving room under the is small compared with that of the fuel, there is no difficulty in taking care of them in this way.

TRANSFORMATION OF THERMAL INTO ELECTRICAL POWER

In sifting out the elements of progress in the engine or turbine room of the power plant it is impossible to separate the steam and electrical units, as each imposes fundamental specifications on the other. This is particularly true in the case of the turbo-generator, and as few power plants are now putting in reciprocating-engine generators, the design of which has been well standardized, attention can be concentrated upon the former.

A noticeable feature of the newest plants is the predominance of horizontal turbines, whereas a few years back the vertical type was very much in evidence. This may be explained by the increased speed which is the order of the day in all rotating machinery. Cast steel can now be obtained of a quality required in the highest speed machines, and speed has, therefore, been pushed up to the limit set by other conditions. At very high speed the horizontal type of turbine and generator is preferred on account of the comparative freedom from vibration.

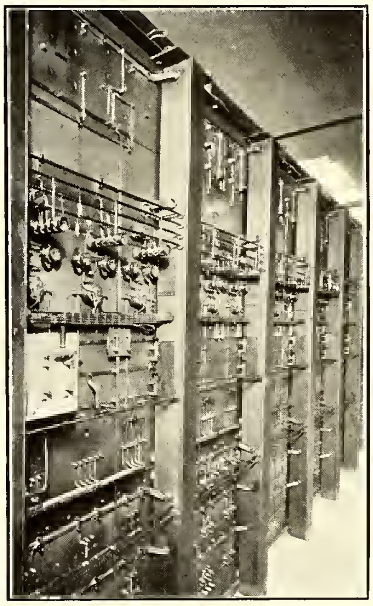
The conditions which now limit speed are the ventilation of the electric generator, which becomes more difficult as its capacity per unit of weight is increased; the provision of ample steam passages in the turbines, especially in the low-pressure stages, and the frequency of the current output of the generator. In machines up to 5000 kw the last-named predominates. At twenty-five cycles a two-pole generator can, obviously, not go faster than 1500 r.p.m., which is a very low speed for a turbine of moderate size. Fortunately, sixty-cycle current is coming into use more and more, even for railway purposes, and in this case the speed limit is set at 3600 r.p.m. At this speed generators of 5000-kva capacity can be built, and as improved methods of ventilation are developed the two-pole alternator will be adapted to still higher capacities. As far as the turbine is concerned, in moderate capacities the speed limit has not been reached. In very large sizes, however, the limit set by frequency cannot be attained. When high and low stage buckets are on the same shaft a speed which is most economical for one is not best for the other. In many recent reaction turbines the high-pressure stage wheels have been furnished with impulse blading, greatly reducing cost and bulk and rendering the use of material more economical. In this case the high-pressure impulse wheels have about the same diameter as the low-pressure reaction wheels, and a given speed therefore suits both. The latest development in relating speed to economy is in the turbo-generators just ordered for the Interborough Rapid Transit Company. Each of these 30,000-kw units will consist of two parts, a 1500-r.p.m. high-pressure and a 750-r.p.m. low-pressure section, the generators having, therefore, two and four poles respectively, as the frequency is twenty-five cycles per second. In this solution of the speed problem the speed of the high-pressure unit is limited by frequency, that of the low-pressure unit by mechanical considerations.

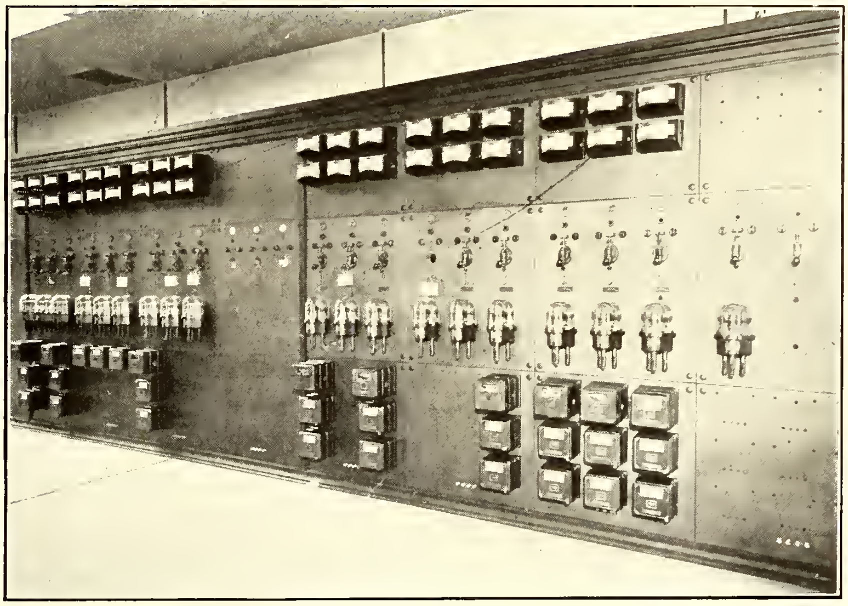
The tendency in turbine design seems to be toward a common type, as the advantages and disadvantages of the different elements are tried out in practice. As higher speeds are used the horizontal type with combination of impulse and reaction blading will apparently be the rule.

SIZES OF TURBINE UNITS

The size and number of units for power plants of different capacity seem not to follow any known law. The general rule formerly followed was to use as few units as would permit operation at high efficiency and yet enough to insure reliability. The early turbines gave, in general, a better economy with the largest possible load, hence it was necessary to keep them well loaded. In later practice the machines are designed to give the best results at average load and good economy over a wide range. It is less necessary now than formerly, therefore, to adjust capacity to demand so carefully. The very large plants contain the largest obtainable units to secure the benefits of small water rate, as there are always enough units for reliable and efficient operation. In the smaller plants large units should also be used, but in general fewer than two would not be safe practice. To indicate present tendencies in this direction a few familiar illustrations may be cited.

The newly completed "Gorge" plant of the Northern Ohio Light & Traction Company contains three 6000-kw, 1800-r.p.m., sixty-cycle units. The Missouri River Power Company's plant, which represents the growth of several years, has two 750-r.p.m. vertical turbines, one 15,000-kw and one 5000-kw, and a 10,000-kw, 1500-r.p.m. horizontal turbine, in addition to several reciprocating engines totaling 15,000 hp in capac-



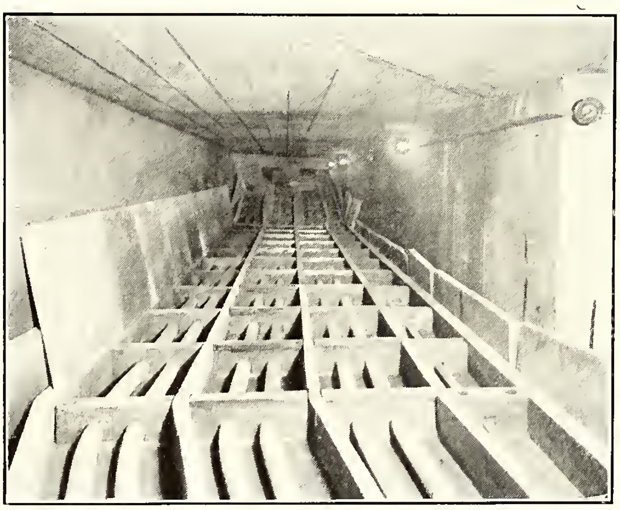


Front and Rear Views of Feeder Panels, Northwest Station, Chicago

ity. The Twin City Rapid Transit plant contains two 15,000-kw, one 14,000-kw and one 5000-kw, 700-r.p.m. vertical turbine. In the new Perth Amboy plant of the Public Service Electric Company there are two 5000-kw, 1800-r.p.m. horizontal turbines. Only two 2500-kw, 1800-r.p.m. horizontal units are used in the new plant of the Kentucky Traction & Terminal Company at Lexington, Ky. The Waterbury station of the Connecticut Company, which forms part of an interconnected system, contains equipment to supplement the output of a large water-power plant. There are four units, all horizontal, two of 1500-kw capacity with a speed of 3600 r.p.m., the others of 3000-kw and 4000-kw capacity respectively and both making 1800 r.p.m. The reserve plant of the Southern Power Company, mentioned earlier, contains one 8000-kw, 1800-r.p.m. horizontal turbine. These examples simply show the existing diversity, due largely to the rapid progress of the art already sufficiently emphasized.

r.p.m. and drives the generator through a reducing gear. In this plant, by the way, the record for July was 3.83 kw per gallon of fuel oil, the load factor being 48 per cent.

The Wisconsin Traction, Light & Power Company has a 1250-kw turbine in the exhaust of two 1000-kw Corliss engines. In this connection an exhaustive analysis reported by M. H. Bronson, chief engineer of the Rhode Island Company, on the installation of low-pressure turbines is of interest. A plant consisting of six engine units of a combined capacity of about 12,000 kw needed to be enlarged. As the fuel economy to be secured by the application of exhaust-steam turbines to the engines was attractive, the plan received careful consideration but was finally rejected (see Electric Railway Journal, Sept. 23, 1911), the reasons being limited space, the probability of soon outgrowing the plant and the expense of repairs to existing reciprocating units owing to their increased loading.



Cable Vault Between Transformers and Turbines, Northwest Station, Chicago

Generator Leads in Cable Vault, Northwest Station, Chicago

LOW-PRESSURE AND MIXED-PRESSURE TURBINES

In the rapid changes which have occurred many plants have in use reasonably efficient engines which cannot be replaced to advantage. On such cases the low-pressure and mixed-pressure turbines offer an efficient means of expansion. A turbine on the exhaust of a non-condensing engine doubles the output without increasing boiler capacity, while one used in connection with a condensing engine may increase the output 40 per cent. By raising the boiler pressure and forcing the firing the combined capacity can be readily doubled. Many such plants are in satisfactory operation, of which the best known is in the Fifty-ninth Street plant of the Interborough Rapid Transit Company in New York City, which contains five 15,000-kw engine-turbine units. In the San Diego Electric Railway Company station the operation of a 1000-kw horizontal low-pressure turbine on the exhaust of a 1200-kw engine unit was so satisfactory that another has recently been added. The turbine carries approximately the same load as the engine and often exceeds it. This is a d.c. plant and the turbine operates at 3600

In the end the engine-turbine unit can be considered only as an excellent means for tiding over the present transition period in power plant history.

CONDENSERS AND PUMPS

Closely connected with the development of turbines has been that of the accompanying condensers. The design of the jet condenser has been improved to such an extent that very high vacuum can be maintained with it. In fact, claims are made that, with suitable pumps, a perfect vacuum can be obtained, the expression "perfect vacuum" being used for a space in which the pressure corresponds to the temperature of the condensing water. Jet condensers are compact, and in view of the rapidly decreasing size of turbines per unit of output this feature is being utilized. Where the quality of water is or can be made suitable for the use of jet condensers their simplicity of construction, low price and low cost of maintenance are leading to their adoption.

The construction of surface condensers, like that of boilers, has been considered fairly well standardized. The demand for large units, however, forces a fresh study of the fundamental principles of design. As the circulation of steam and condensate and the design of pumps are improved the rating can be increased. It is possible now to absorb 500 b.t.u. per hour per square foot of surface. In St. Louis recently 12,000-kw turbines were substituted for 5000-kw turbines without change in condensers and the same vacuum was maintained during the winter, being only slightly reduced in summer. As the supply of condensing water available for many large plants is either salt or dirty, the surface condenser obviously will continue to hold its place.

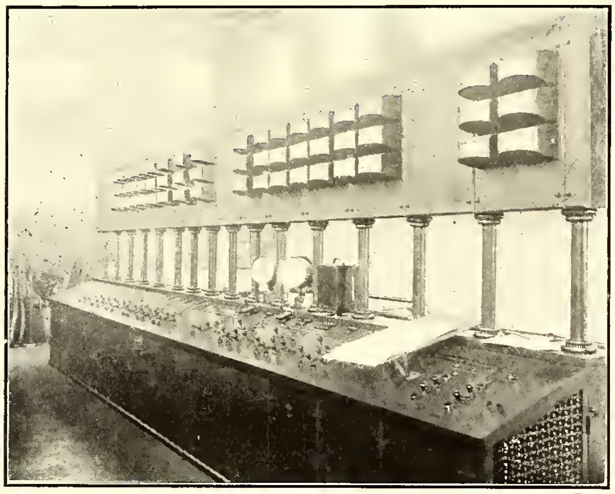
An interesting commentary on the superiority of the surface to the jet condenser for use with dirty water is found in the remodeling of the Twin City Rapid Transit Company's plant. Four 3500-kw engines installed in 1905 were furnished with four jet condensers, including one of the barometric type. The feed water was filtered by means of a complete mechanical sand filter plant capable of removing 98 per cent of suspended matter for 1200 gal. of water per minute. This foreign matter included the debris from the Mississippi River and the oil contained in the condensate. The turbines which have replaced all but one of the engines have had surface condensers, it having been proved to be more economical to use them rather than to enlarge the filter in accordance with the increase in capacity of the plant. The filter now purifies only the make-up water and the house supply. The absence of oil from the turbine exhaust renders unnecessary the filtering of the condensate.

In the matter of type of air pump used with condensers the reciprocating pump is superior from the standpoint of steam consumption, and if no economizers are installed so that more steam is produced from the auxiliaries than is required for heating purposes this economy may be important. The turbine pump is inherently simple and when all exhaust steam can be utilized it would appear that turbine pumps will be increasingly used.

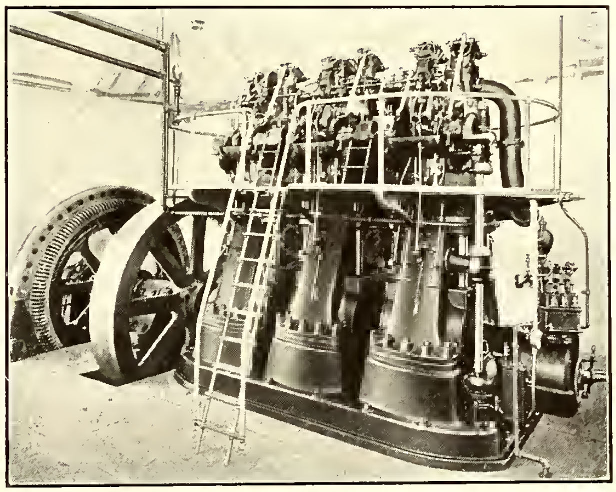
ALTERNATOR DESIGN PROBLEMS

At the generator end of the turbine unit the problems are now largely those of keeping down the temperature and improving insulation to resist the effects of higher temperatures. From the mechanical standpoint the rotating field core can be designed for as high a speed as 3600 r.p.m. in sizes up to 5000 kva. The peripheral speed may be 25,000 ft. per minute or more. Steel plates about 2 in. thick are frequently used in building up the cores, as a very uniform quality of material can be thus secured. Owing to the high speed of the modern machines the number of poles required is small and the mechanical construction of the rotor is reasonably simple.

Both radial and parallel slots are used in rotor construction. Cores made with the latter give better support to the end turns and can be much more easily wound. The radial slot cores use the material more economically, as more surface can be covered and better ventilation is provided. The selection of the proper type is a designer's problem and does not concern the operator unless one is more durable than the other, which it apparently is not.



Benchboard in Turbine Room, Twelfth Street Power Station, Richmond

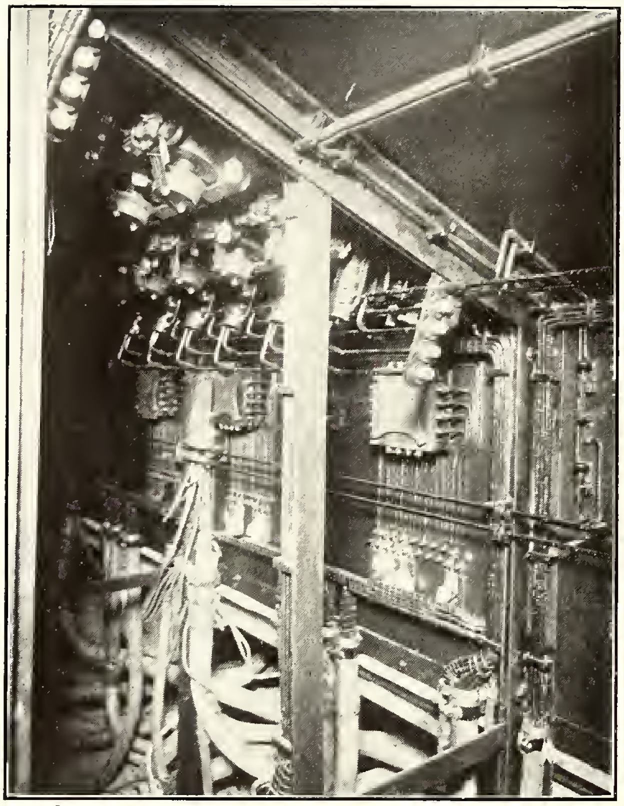


Diesel Oil Engine with 375-kva Generator, a Possible Rival for Small Steam Turbines

In armature design the great difficulty has been to keep the winding reasonably cool. In the old slow-speed alternators there really was no ventilation problem, attention being concentrated on regulation. In the compact turbo-generator ventilation furnishes a large part of the problems owing to the small space over which the heat must be liberated. Where a 5000-kw engine-driven alternator might have had a rotor diameter of 26 ft. the same capacity can be secured now with 26 in. The armature windings have corresponding diameters, and the amount of air which must be forced through the armature winding is very great. In a recent paper B. G. Lamme estimates that a 150,000-kw machine requires 50,000 cu. ft. of air per minute. To perform its function this air must come into intimate contact with the winding and cores, and the forced circulation involves increased loss due to air friction in the passages. The circulation may be secured either by fans mounted on the ends of the rotor or by separate blowers. The latter method is increasing in favor because of its higher efficiency and the possibility of control which it affords.

Axial ventilation ducts under the armature teeth with one large radial duct in the center for the exit of air are also being used in place of numerous radial ducts.

Artificial cooling of air has lately received some attention especially in connection with washing. This seems to furnish a most promising means for improving ventilation. As generators are rated on the basis of temperature, their capacities are greater in winter than in summer. A reduction of 20 deg. in temperature with a fairly high humidity such as is produced by a washing device will equalize the capacity between winter and summer. Cooling devices would have made more rapid progress in connection with generators but for the fact that power plant loads are heaviest in mid-winter. The straining or washing of the air is more important than cooling it, as the accumulation of dirt in the ducts cannot but produce overheating. These refinements must have more attention in the near future.



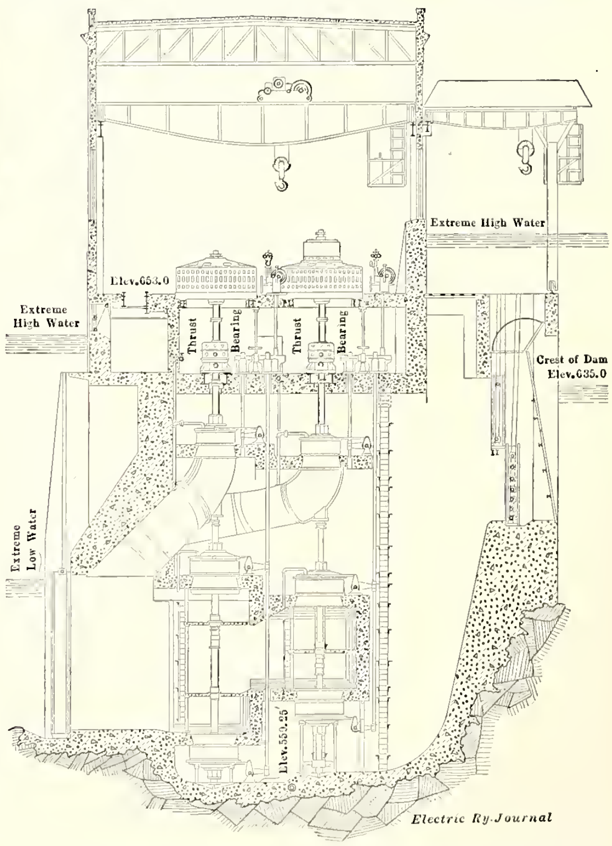
Rear View of Benchboard, Northwest Station, Chicago

With all of the improvements in ventilation, internal temperatures are bound to rise. The present A.I.E.E. rating is based upon the properties of cotton, paper and shellac. In modern machines mica and asbestos are largely used. The use of these will allow windings to be run hotter, and thus generators will be cheaper per unit of output. Insulation practically fireproof can now be applied to high-tension windings and a higher rating can well be allowed with its use. It must be said, however, that the actual tendency on the part of purchasers seems to be in the direction of conservative rating.

The mechanical support of armature windings is closely connected with their electrical reactance. A few years ago the reactance was kept reasonably low, not, of course, as low as possible, because even with slow-speed alternators reactance was depended upon to protect the windings from the effects of short-circuit. These effects were principally electrical. The reactance value used was a compromise between a low value for good regulation and a high value for protection. Now protection against the mechanical effects of short circuit is considered most important and reactance is made as large as the design will permit, supplemented, if necessary, with extra reactance in the transformers or even in special reactance coils connected in the circuit. If better regulation than is given by the generators is required, it can be readily provided by automatic regulators in the alternator or exciter field circuits.

EXCITATION

In the matter of excitation there is great diversity and much mobility of practice. From one point of view the exciter plant can be looked upon as an auxiliary station from which absolutely reliable service must be had. This plant will usually contain two or three sources of power, one or more steam units, usually turbine-driven, one or more motor-driven units, and a storage battery arranged to be automatically thrown into action if other sources fail. This may be said to be general practice at present. The other plan is the use of individual exciters either direct-driven or motor-driven. There is evidence of the increasing popularity of the latter plan for very large units. The first plan is economical of equipment and insures reliable service. It does not permit regulation by adjustment of exciter voltage and the size of conductors to



Cross-Section of Hale's Bar Hydroelectric Station

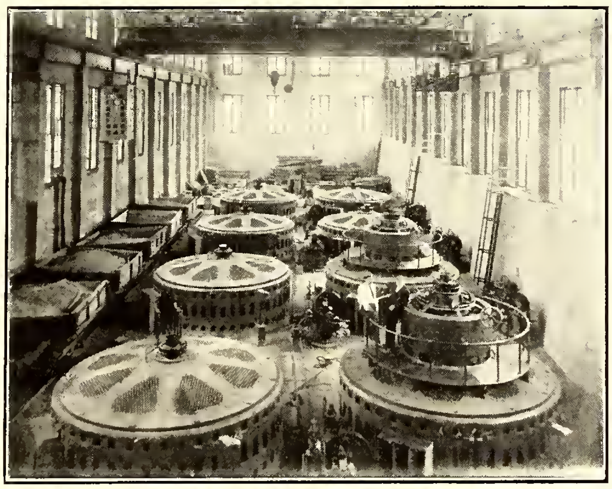
large alternators is considerable. To offset these features the direct-connected exciter is doubly expensive from the fact that it must be made extra large to permit it to care for the load of another machine should it be disabled. A complicated system of interconnection is also necessary.

The standard voltage for exciters for moderate-size machines is 125. Double this is used in very large units to obviate the use of very large field conductors, field switches, field rheostats and busbars. In such cases the higher voltage equipment is cheaper.

WATER POWER FOR ELECTRIC RAILWAYS

Few electric railways are so fortunate as to have water power near enough at hand to make its utilization possible, so that water powers are of secondary interest to railway men. At the same time an increasing amount of power is being served to electric railways by companies making a specialty of power generation and transmission from waterfalls. Notable recent instances of this are found in St. Louis, Baltimore, Portland (Ore.), Atlanta, Syracuse (Beebe lines) and many other places. On account of the lower speeds used in hydraulic machinery the problems of ventilating electrical generators are much simpler than those connected with steam machinery. Otherwise the electrical situation is the same as in steam stations. The prime movers in the hydraulic station are much simpler in every way. As, however, every plant imposes different specifications, no general statements as to tendencies are possible. A conspicuous fact, however, is the excellent efficiency now being obtained both with the horizontal and the vertical wheels.

With fuel so increasingly expensive in many parts of the country water power should be able to compete with steam for railway purposes if it can be furnished reliably. That it can be is indicated by the fact that Niagara power has long been successfully operating cars in Buffalo, Toronto, Rochester, Syracuse and elsewhere. Among more recent examples is the delivering of power in Baltimore from the Pennsylvania Water & Power Company's plant at McCall's Ferry on the Susquehanna River. There are in operation in this plant now six units of a total capacity of 44,500 kw, and plans are already being made for extension. The generator voltage is 11,000, which is raised to 70,000 for transmission, and at Highlandtown, a suburb of Baltimore, it is lowered to 13,200 for local distribution. This plant operates under a head of about 60 ft. and the speed of the vertical turbines is 94 r.p.m. A still more recent newcomer in the supply of hydraulic power to railways is the Mississippi River Power Company, which now has its lines operating into St. Louis. One of the most recent plants is that of the Chattanooga & Tennessee River Power Company at Hale's Bar. In this, as shown by the accompanying illustration, the unusual arrangement of three waterwheels on each shaft has been adopted. During periods of low water, when the effective head is large but the available flow is small, the upper wheel on each shaft is shut off and its casing drained, thus permitting it to turn free in air.



Generator Room, Hale's Bar Hydroelectric Station

Power House and Part of Dam, Hale's Bar Hydroelectric Station

One factor in the development of water powers is the increasing use of networks of transmission lines fed at different points from water and steam plants. Most water supplies are so variable that if the full low-water capacity of the stream is utilized the power is at times quite uncertain. Further, as water-generated power is transmitted over long-distance lines, troubles may interrupt service. Multiple-station supply tends toward continuity, especially if plants are located on different streams and if one or more steam plants are included in the scheme. Even in such an extensive chain of plants as that of the Southern Power Company it has been found necessary to provide an auxiliary steam supply. The Niagara, Lockport & Ontario Power Company is rapidly pushing to completion an auxiliary water-power plant on the Salmon River near Syracuse. This is not so much to provide a reserve, the supply of Niagara power being unlimited up to the capacity of the transmission lines, as it is to supplement the Niagara power used in rapidly increasing amounts in central New York. It will, however, furnish additional assurance of continuous service. The Mississippi River Power Company will utilize existing steam plants in St. Louis as a reserve. The Twin

City Rapid Transit Company has in Minneapolis two hydraulic plants, one utilizing the full flow of the Mississippi River up to the capacity of the plant, the other the surplus water not needed by the flour mills. In conjunction with these is a steam station taking the surplus load, which is small when the water supply is good. The Portland Railway & Light Company has completed its 25,000-kw Bull Run plant, 30 miles from Portland, to supplement its other supply sources. This contains three 514-r.p.m., 3750-kva, 6600-volt, sixty-cycle units operating under a 325-ft. head. The voltage is stepped up to 60,000 for transmission. All of the above examples are cited simply to suggest that, while hydraulic plants are apt to be remote from the experience of most railway men, this source of cheap power is having a continually closer relation to the railway business.

TRANSMITTING POWER FROM GENERATOR TO SUB-STATION

In traction work simplicity and reliability are the important factors in the transmission of electric power. Standard apparatus is therefore largely used. The newer and more fascinating developments and experiments are largely connected with very high voltages, and these, in general, do not directly concern the electric railway operator. There is, however, a great deal going on in high-tension transmission, voltages up to 150,000 being now in commercial use.

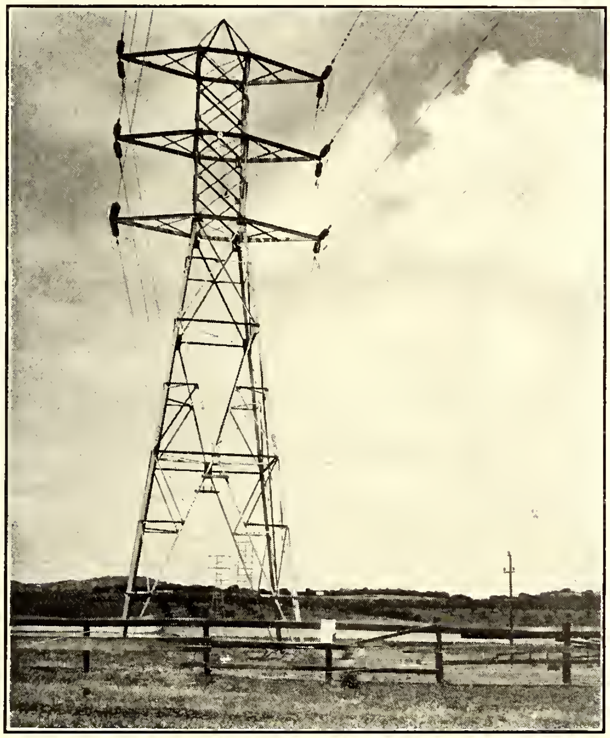
Usual generator voltages in railway plants are now 2200, 6600 and 13,200, the last-named being on the increase. For transmission purposes 33,000 is still sufficiently high for the areas over which railway power is usually distributed.

The oil-cooled type of transformer with water coils seems to be preferred for the power house end of the line. These transformers are made with high reactance to keep down short-circuit current. While it is probable that the three-phase unit is increasing slowly in popularity, separate transformers are still preferred, especially where there are but one or two banks. The lower cost and smaller floor space required for the three-phase type should eventually lead to its use.

Whether delta or star connection of transformers is best is still open to debate. For the generator side the delta seems the natural connection, as the argument for the use of three units is that they can be operated in open delta if one is injured. The star connection is cheaper,

Terminal House of Cataract Power & Conduit Company with Tower for 1700-ft. Span Across Niagara River

as the windings are insulated for lower voltage and there are fewer turns. On the line side the star connection is convenient for grounding the neutral, but, on the other hand, with grounded neutral the grounding of a line short-circuits a winding, so that this argument in favor of the star connection is by some not considered important. On the whole, it is probable that a delta high-tension and a star low-tension connection is average practice. In Minneapolis, where many of the transformers have delta-delta connections, a large grounding transformer with star primary and delta secondary is connected to the busbars and the neutral is grounded through a resistance of 12 ohms. This device has eliminated troublesome surges and has also served as a ground detector, the ammeter of an offending line promptly showing that extra current is flowing in it.

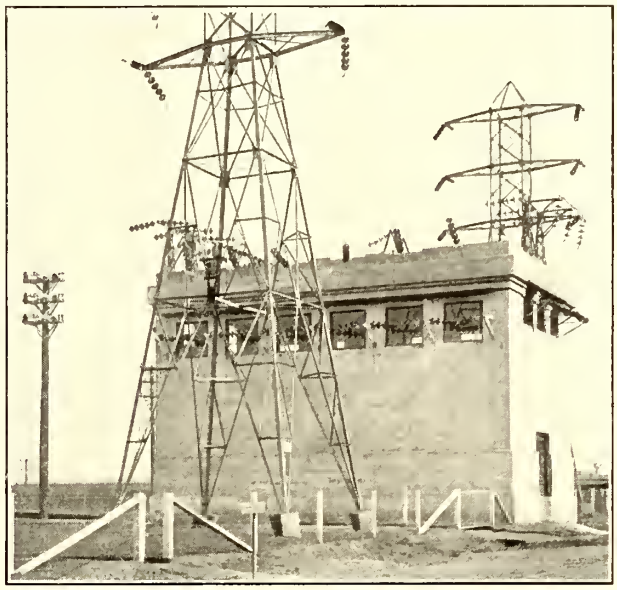


Typical Dead-End Construction on 100,000-Volt Line, Great Western Power Company

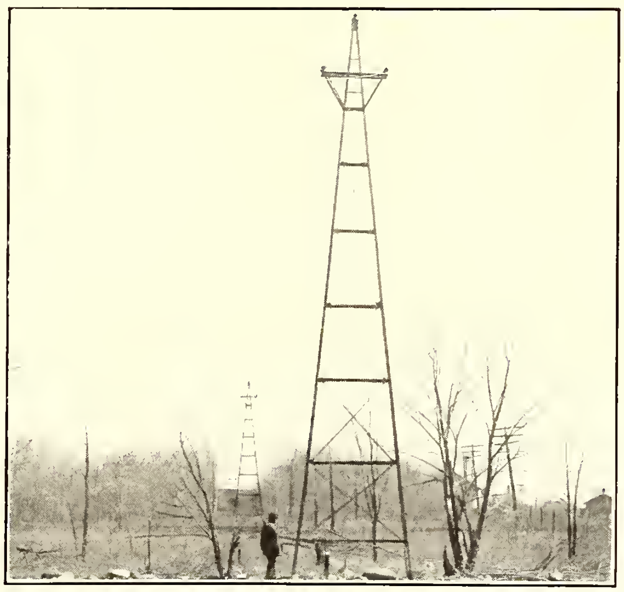
SWITCHBOARDS AND SWITCHES

The simplicity of the bench type of switchboard, especially for generator control, seems to be appreciated. Properly placed in a centrally located gallery the benchboard permits the operator to see instruments, generators and switches without turning. The oil switches controlled from this board can be located anywhere, even in separate buildings if desired. For the control of line oil switches panelboards are satisfactory. In spite of a recognition of the general principles of the selection and placing of switchboards, there is much diversity of practice in this line, as each station appears to present a peculiar switchboard problem. Obviously, if standard forms of equipment can be used it is better to conform the requirements to the available supply than to insist on special design. There is an evident tendency to do this.

The use of remote-control switches gives excellent opportunity for the application of automatic relays and much ingenuity is being displayed in this direction. There is no difficulty in opening circuits of moderate voltage automatically, but very high-tension lines must be opened more cautiously to avoid surges. Inverse time-limit relays are in general use for protecting generators and reverse-power relays are the latest development in the protecting of defective machines from rushes of current. A curious result of careless arrangement of oil-switch auxiliaries was described in the technical press recently. In the plant described the relays, speed-limiting devices and turbine-speed control were all supplied with power from the exciter system. A piece of a casting dropped into the

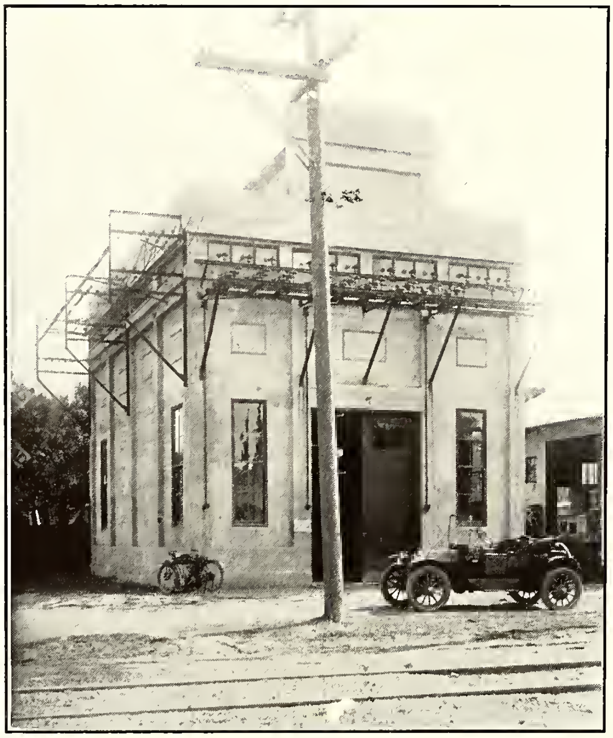


Sectionalizing Station, Great Western Power Company



A-Frame Tower for Transmission Line, New York State Railways

generator air gap of one of the units, wrecking and grounding the field winding and putting the exciting system out of commission. As a result the oil switches failed to open and the turbine governor opened up, allowing the unit to run away. The high voltage produced as a result



Substation at Sacramento, Great Western Power Company

did much damage, and this was aggravated by the substation storage batteries, which, not being protected with reverse-current relays, operated the rotaries inverted. This was an extreme case, but it indicates the results which may occur from the lack of proper relays and explains the great activity displayed by designers in the improvement of the automatic control of switching equipment.

TRANSMISSION LINES AND CABLES

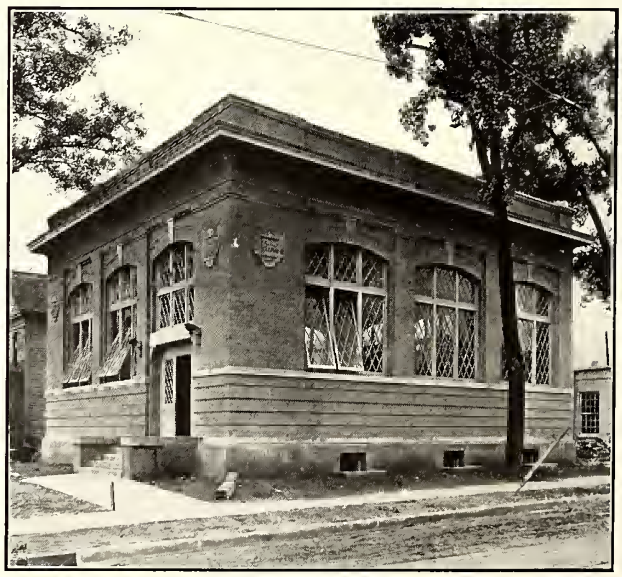
In transmission lines the tower construction is used in most of the large systems supplying electric railways over long-distance lines. These usually belong to power transmission companies having water-power plants, hence interest railway men only indirectly. There are many lessons to be learned, however, from some of these installations.

As an example representing very recent practice we may cite the Pennsylvania Water & Power Company's line into Baltimore, in which four-legged galvanized steel towers, spaced about 500 ft. apart, of a standard height of about 44 ft. to the lowest cross-arm, are used. The aluminum wires of the double three-phase line are suspended 15 ft. apart in vertical planes by means of five-unit suspension insulators. The Canadian Light & Power Company also uses steel towers 52 ft. high and with 500-ft. span, but prefers pin-type insulators. A cheaper form of tower which will undoubtedly be used in railway work more and more is the A-frame or flexible steel tower. One of the first installations of this kind was made by the New York State Railways. This frame construction requires anchoring along the line but has the advantage of flexibility as well as cheapness. As one of the points in favor of the suspension insulator is the flexibility which it gives along the line, the same argument should apply to the use of the flexible tower of the A-frame type.

At present when railways own their own transmission lines, wood or concrete poles are found more economical than towers, as lower voltages are used and less power has to be transmitted. There has not been any important change in wooden-pole construction, but much progress has been made with concrete poles. The New York State Railways, for example, is using these in sizes up to 45 ft. with good satisfaction.

In protecting lines from lightning the electrolytic arrester now holds the field. It is used for the highest line voltages as well as for the lowest d.c. distribution voltages. For the high-voltage lines the cone type with series horn gap is used, the cell type being adapted for the other. The cone-type arrester requires care in its operation, but in return it gives protection. Formerly the lightning arrester was supposed to take care of itself and the result was dissatisfaction all around. At present much less is heard about lightning disturbance.

Underground cables are being insulated for higher voltages, although the details of the processes of manufacture are kept as secret as possible by the manufacturers. Cables insulated entirely with rubber are not recommended for high voltages, as rubber deteriorates rapidly under the action of the ozone generated by the potential in the air and moisture in the jute fillers or material used in rounding up the cores. The composite insulation is made up of



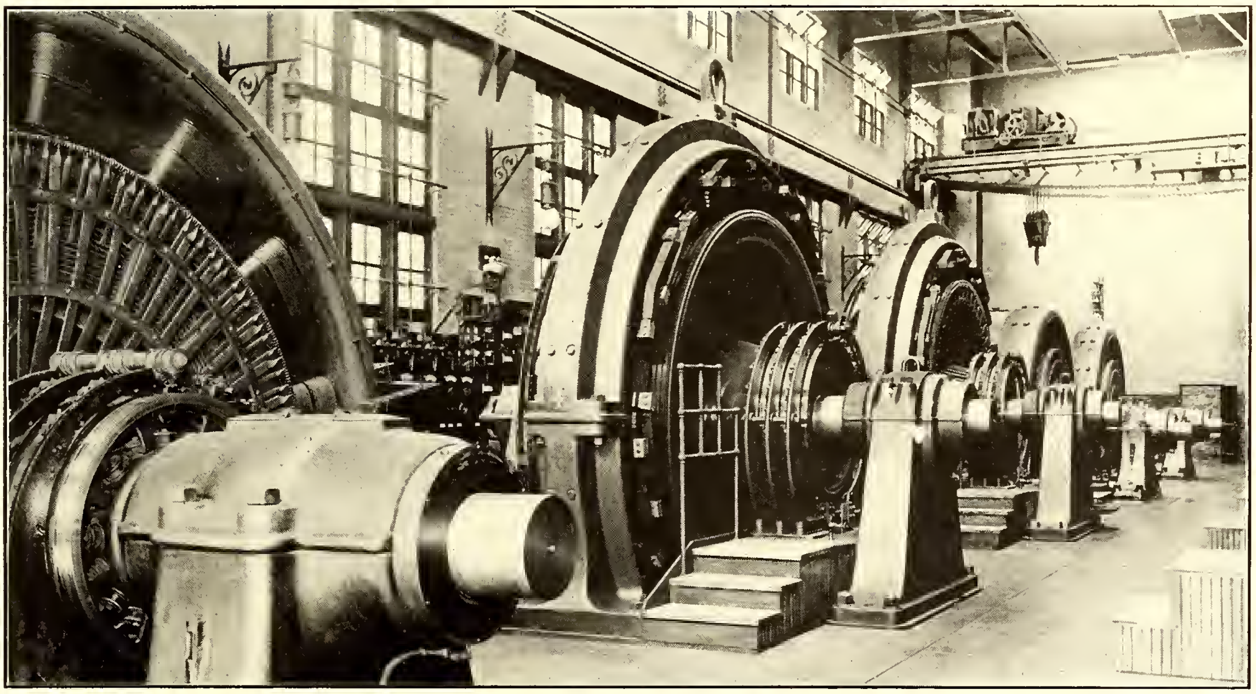
Typical Substation, Twin City Rapid Transit Company

rubber and varnished cloth with the former next to the core. In connection with the cables improvements are being made in pot-heads and other forms of terminals, which formerly were very troublesome parts of the equipment.

SUBSTATIONS

Two important factors have operated to produce changes in substation construction in the past few years. The application of the commutating-pole principle has permitted the increase in speed and the corresponding reduction in size of rotary converters. At the same time the spread of central-station power in the railway field has tended to encourage the development of sixty-cycle converters, which can be constructed much larger with the commutating pole than without.

The present two-frequency situation acts as a barrier to the taking on of railway load by central stations and the securing of light and power business by railway companies. It has all been brought about by the low-frequency rotary converter. Either two kinds of generating equipment had to be maintained or frequency changers used, or in some cases both of these conditions existed. Low frequency was necessary because the danger of "flashing-over" set a lower limit to the distance between brush studs, while the allowable commutator speed, 3000 ft. to 4000 ft. per minute, limited the rotative speed of the armature. Sixty-cycle converters were built in small sizes many years ago with fair success even before commutating poles were introduced, but it was the commutating pole that revolutionized converter practice. It has done this by improving commutating conditions, thus rendering unlikely the disturbances which cause flashing. It has also made possible the use of higher commutator and, therefore, higher armature speeds, thus permitting a reduction in size as well as an increase in frequency. Before adopting the sixty-cycle converter on a large scale the engineers of the Cleveland Railway Company conducted some experiments with twenty-five-cycle converters run at an abnormal speed to produce sixty cycles. The result was entirely satisfactory, proving that high speed would not interfere with good commutation.



Interior View of Substation, Chicago Railways, Showing 3000-kw Rotary Converters

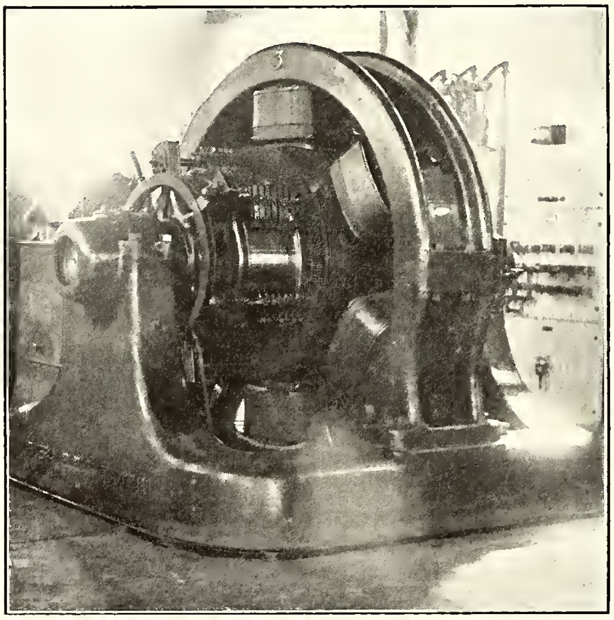
The situation outlined above is being changed rapidly, rendering impossible the determination of any standards, as engineers cannot predict what is coming next. That the sixty-cycle substation is the coming thing is, however, practically certain. Practically all small converters are now sixty-cycle and larger sixty-cycle machines are being built continually. Capacities up to 2500 kw at 500 volts, which is the equivalent of 3000 kw at 600 volts, are entirely successful.

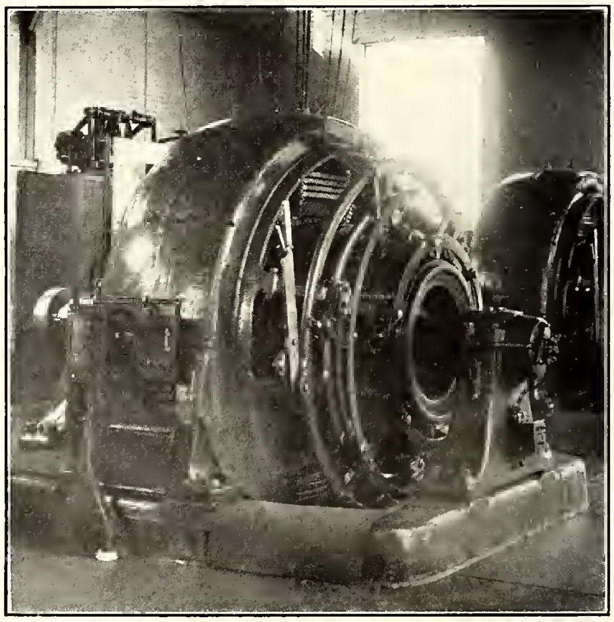
Due credit should be given the Cleveland Railway Company for its confidence in the sixty-cycle converter as shown by its adoption on a large scale last year. While the important electrical manufacturing companies were willing to undertake the construction of the machines, the operating company had much more at stake in this decision, as it had to determine whether to build a new power house or to purchase energy from the Cleveland Illuminating Company. In deciding upon purchased power the matter of frequency came into prominence, as sixty-cycle is the standard frequency of the lighting company. By adopting this frequency the railway company obviated the use of motor-generator sets at a great saving in cost and power loss. In selecting these converters the purchasing company specified unusually liberal allowances of iron and copper, partly to provide a heavy armature, and the result is an armature weighing 10 tons. The purpose of this great mass is to provide a flywheel effect to pull the machine through heavy sudden overloads, but it is probable that with the experience gained in this and other installations the converters can be made much lighter and cheaper.

An important condition which favors the high-frequency converter is the steady nature of the output of the steam turbine. Its speed is so nearly constant that the frequency is not subject to sudden variations, hence the absence of shifting of the phase position of the rotary armature currents and the consequent disturbances of commutating conditions.

ROTARY CONVERTER SPEED AND CAPACITY

In the reduction of size one of the interesting machines of the year is a 1000-kw, 750-r.p.m. converter installed in the Townsend Street substation of the New York State Railways at Syracuse. This stands about one-half as high as its 375-r.p.m. neighbor of the same capacity and representing the standard practice of a few years ago. The two machines are shown side by side in the illustrations on page 544. The difference in size is due not only to the high speed but to the improved methods of ventilation and the reduction of losses which have necessarily accompanied the reduction in size. That this is true is shown also in the substation of the Buffalo Railway Company, where a 400-kw, twenty-five-cycle converter, a large machine ten years ago, stands by the side of a 1000-kw converter of the same speed. The heights of the two are approximately the same.





Views of 1000-kw Rotary Converter with Commutating Poles and of 400-kw Old-Style Machine of Same Speed, Reproduced on Same Scale to Show Approximately Equal Size

Accompanying the reduction in size of converters of a given capacity is the use of larger units. When 2000-kw units were adopted principally in the very large cities they were considered remarkable. Now 4000-kw machines are considered the standard in Chicago at least, and although as yet the actual number installed is not large, it is being largely increased. The reason for this is that, as the efficiency of conversion is very high over a considerable range of load, economy of floor space, switching apparatus, foundations, building transformers and attendance dictates the use of as large units as can be economically loaded. The arguments are exactly the same in this case as in that of the power house. In fact, they are stronger because substations are usually located on more expensive real estate than are power plants.

In substation transformers the air-cooled type is popular on account of its compactness. A recent improvement has been the elimination of the outside case, exposing the core. This gives increased space economy and better radiation. Transformers of this type of 1050-kva capacity were recently installed in the Snelling Avenue substation of the Twin City Rapid Transit Company.

SUBSTATION LAYOUT

The requirements in substation layout are fairly uniform throughout the country, and in spite of changes in rotary converters and in details of equipment the general plan is affected principally by the form of the site. The station is planned to operate with a minimum of labor; that is, one man to a shift if practicable. In general there is a row of converters near the center line of the room with axes perpendicular to its length. Behind these are the reactances and starting panels, next a row of air-blast transformers and another row or two of motor-operated oil switches. The busbars may be on the main floor or in the basement, practice in this feature being divided. The a.c. control board and the d.c. generator and line panels are along the wall facing the line of converters, with ample space behind. The building is usually of brick with roof supported on light steel trusses and a crane is provided for handling apparatus.

In the basement are the high-pressure air chamber under the transformers connected with the fans by underground ducts, the inductive shunts for the converters, in some cases the bus chambers, usually with the high-tension flat bars or tubes separated by brick and concrete barriers, a storage battery room for the switch-operating battery, an electrolytic lightning arrester cabinet, a ground bus, a compressor equipment for supplying air for cleaning machinery, and the usual locker and toilet rooms.

If numerical data are added, this description will cover a large proportion of the newer substations used for railway purposes.

STORAGE BATTERIES

In the above outline no provision is made for storage batteries for heavy duty. Where such are used they are housed in separate buildings if possible. The function of such batteries is largely to act as a reserve, but they also assist in reducing load peaks, an important consideration where energy is purchased. The status of the battery in the substations of the future is in some doubt on account of the expense of maintenance on the one hand and the increasing reliability of direct supply on the other. In many cases the battery is practically necessary even if scarcely ever used. If discharged only frequently enough to insure healthy condition, as is the practice of the Commonwealth Edison Company of Chicago in the treatment of its lighting batteries, the maintenance cost is very low. If, on the other hand, daily heavy discharges are the rule, the deterioration is rapid.

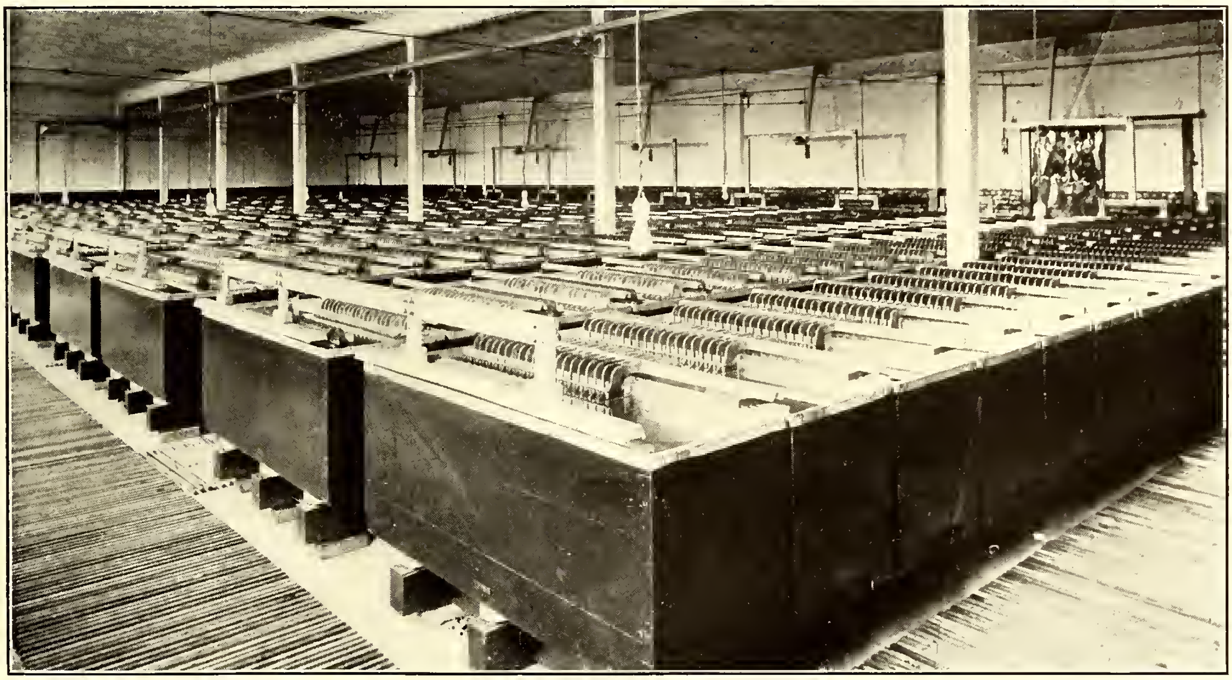
The International Railway was a large and early user of storage batteries and now has a large equipment in daily operation with excellent results. These batteries are used to assist in keeping down the peaks of the load on the Niagara Falls Power Company's lines, resulting in a reduction in the cost of the energy amounting to more than the battery maintenance and loss costs. They are discharged every day, excepting holidays and Sundays, at a high rate.

These batteries have now been in use about ten years, so that the cost of maintenance per kilowatt-hour can be determined in the light of long experience. The cost figures for the three Buffalo batteries for three years are given in the following table. The high cost for the year 1911 is explained by the fact that during that year it became necessary to move one of the batteries and reinstall it owing to the condition of the battery room floor. This entailed an expense of $5,000. The cost per kilowatt-hour output given below does not include fixed charges. The original cost of the battery was approximately $265,000, to which must be added the cost of buildings, etc. The battery is now, however, in a condition equal to new, as required by the maintenance contract between the manufacturer and the railway company.

Table Showing Output and Cost of Output per Kilowatt-hour Buffalo Storage Batteries

Year	Kilowatt-hour Output	Cost per Kilowatt-hour Output
1909	2,369,539	$0.0105
1910	2,240,785	0.0108
1911	2,426,665	0.0131

In case the battery can be made partly or wholly to pay for itself, as in the above instance, the insurance against breakdown is secured cheaply. The old argument for the use of the battery, that it enables the load to be held at a uniform value and thus effects improved economy, no longer holds. In the first place, modern machines operate at high efficiency over wide range of load; second, the losses in the battery are so great that they more than offset any possible saving. As a regulator of voltage the battery undoubtedly does have some effect, but voltage regulation can now be secured more cheaply in other ways.



Interior View of Typical Storage Battery Room, with Batteries Floating on Line, International Railway Company, Buffalo

SPECIAL SUBSTATION TYPES

In the lighting field the outdoor substation is making progress, the extra expense for transformer insulation being small compared with the cost of buildings. This practice has not yet been extended to railway work except in a few isolated cases of portable substations. There would seem to be many reasons in favor of the use of outdoor transformers in connection with rotary-converter stations, which could thus be made smaller and simpler. All blowing apparatus, high-tension entrances and other details could be eliminated and the buildings reduced to much smaller dimensions.

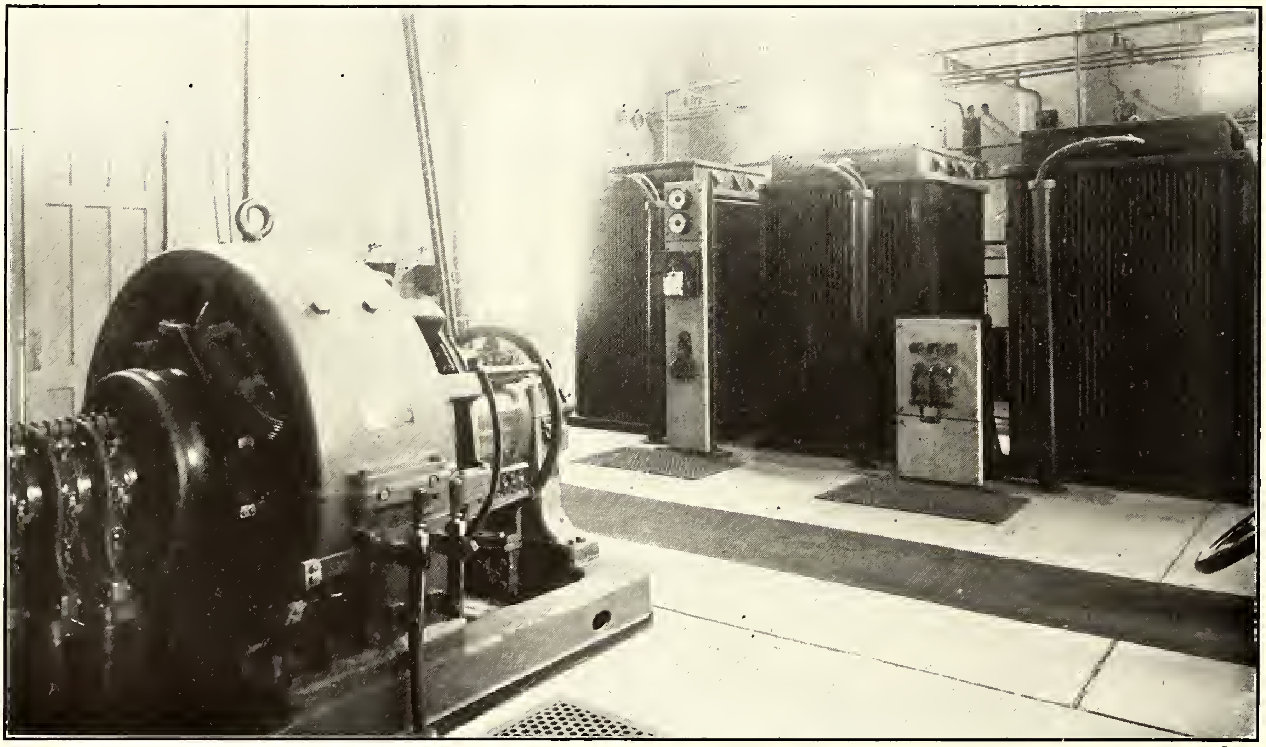
The portable substation is finding an increasing field of usefulness in temporary service. The high-speed, high-frequency rotary will make larger units portable, and by the use of specially cooled transformers portable substations can be made of almost any desired capacity. A recent car designed by the Northern Ohio Traction Company was described in the issue of the Electric Railway Journal for Aug. 16, 1913. The use of a sixty-cycle, 900-r.p.m., six-phase rotary here results in a high space efficiency, a density of 1.73 kw per square foot of loading space being obtained.

THE EVOLUTION OF THE POWER PLANT

Occasionally a railway company has the opportunity to put up an entirely new plant, and in this can be realized the ideals of the designers provided they involve reasonable expense. In most cases, however, the plants existing to-day have "evolved" from earlier ones bit by bit. In the first paragraph of this article indirect reference was made to the stubborn fact of obsolescence. It takes courage as well as money to retire a machine still in its physical prime simply because another one can do its work so much more cheaply that the capitalized saving more than offsets the depreciated value of the other. This replacing process, however, is necessary. It is taking place on a larger or smaller scale all over the country. The 5000-kw turbines which were placed in the Fisk Street station of the Commonwealth Edison Company eleven years ago were replaced almost immediately with units of more than twice the capacity on the same floor space.

Now the same company is putting 25,000-kw turbines in approximately the same space. Hence these early machines play their expensive part in following the laws of obsolescence, and one stands in the yard of the General Electric Company to-day as a monument to progress in power-generating methods.

A most conspicuous illustration of the operation of this law is found in the changes in the power plants of the Interborough Rapid Transit Company of New York City which are being partly made over to provide power for the new subways. Splendid Corliss engines have been sold to make way for the new 30,000-kw cross-compound turbine units which will be installed in the same buildings as their predecessors. In a recent article Dr. Louis Bell gives an example of obsolescence in a much smaller plant which in twenty years has had practically three equipments. This is probably true of most railway plants of the same age, or it will be by the time that impending changes are inaugurated. In the first stage there were slow or high-speed engines with belted d.c. generators. Then came direct-connected d.c. generators or, in some cases, alternators. Now these are rapidly being retired and turbines, mostly of the horizontal type, are taking their places.



View Showing Small Floor Space Occupied by Modern Rotary Converter in Comparison with Its Transformers, New York State Railways

DESIGN OF CITY CARS

JUST a decade ago, in the 1903 convention issue of the STREET RAILWAY JOURNAL, the principal city cars of that period were described under the heading of "Standard Practice in Rolling Stock for City Service." The semi-convertible and convertible drop-platform types had then been developed to a high standard of efficiency, while more localized designs like the California open and closed compartment, the Ohio open and closed side and the Denver side-entrance cars were practically at a standstill. The double-deck car had become a memory. The most startling novelties of the day were vestibuled platforms, the Detroit rail for the segregation of smokers and the accelerator door to save one step between the street and the car body. Discussion of car design was confined almost wholly to the long car versus the short car, and the significant objection which was urged against the use of the former was the loss in missed fares during the rush hours. Such economic questions as weight reduction were hardly considered. As for operating problems, the folding gate of the Twin City Rapid Transit Company represented the only device then in use for the prevention of platform accidents.

While matters were in this stagnant state, the Montreal Street Railway Company, through W. G. Ross, then managing director, and Duncan MacDonald, then superintendent of the company, was quietly working out a system of pay-as-you-enter fare collection which was destined to revolutionize city car design, construction and use. The prepayment system was inaugurated at Montreal in 1905 with little change in the original cars except the provision of longer platforms, passenger-dividing rails and front exit door under the motorman's control. Its success in reducing platform accidents and increasing traffic receipts was soon brought to the attention of American street railway operators, and the year 1907 marked orders from Buffalo, Chicago, New York and Newark for equipment with prepayment features. From that year onward, changes in car-body construction, platforms, doors, steps, etc., occurred with such amazing rapidity that the following review must be considered only as a snapshot of conditions as they are in September, 1913.

The principal advances in rolling stock, as hereinafter described, may be summarized as follows: wooden underframes superseded by plated wood, composite wood and steel, all-steel structural members or side girders with bottom members for floor support only; wooden superstructure superseded by sheathed sides, steel posts and carlines; wooden veneer inside finish and headlining superseded by composition and metal; wooden floors replaced by monolithic material; monitor and steam coach roofs changed to single-arch design; the introduction of an endless variety of railed platforms and of doors and gates manually or automatically operated by the crew in connection with folding or sliding steps; monitor sash ventilation superseded by exhaust and forced ventilation; incandescent lamp lighting replaced by metallic filament lamps, and the introduction of push-button and door signal systems.

Stepless Car of the New York Railways Company

THE USE OF STEEL FOR CAR FRAMING

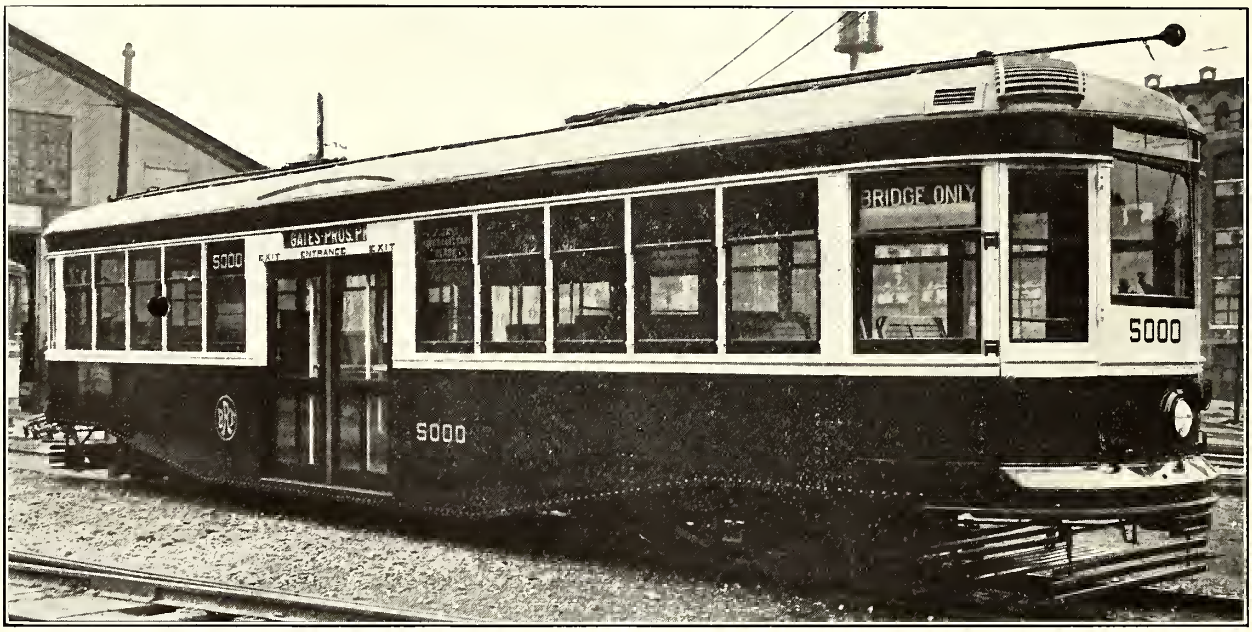
The advance in car framing may be appreciated from a description of the bottom framing of a Brill semi-convertible car with 30-ft. 8-in. body, as presented in the STREET RAILWAY JOURNAL for Nov. 28, 1903. In this car the side sills were of 4-in. x 7¾-in. long-leaf yellow pine with a 12-in. x ⅜-in. sill plate on the inside. The center sills were 3½ in. x 4¼ in. and the end sills 5¼ in. x 6⅞ in. The center platform timbers were reinforced by 4-in. x 3-in. x ½-in. angle irons. The posts and carlines were also of wood. This construction was almost universally standard in 1903, but two years later the Twin City Rapid Transit Company built some trial cars with all-steel underframes.

The first Eastern city car with all-steel underframe was built the same year by The J. G. Brill Company for the Ocean Electric Railway, Long Island, N. Y. Like the wooden semi-convertible car previously mentioned, it was 30 ft. 8 in. over the body. Its side sills were composed of two flanged members with the flanges meeting, castings being placed between the members to serve as spacers and also as sockets for the tenons of the grooveless posts. Structural steel was also adopted for the other members of the bottom framing of this car owing to the fact that it was to operate over a third-rail line for part of the way. The reduction of the fire hazard was also a strong consideration in the choice of steel for the subway cars built about this time for Boston, Philadelphia and New York. Pressed-steel cars were furnished to San Francisco and Montreal during 1907.

MODERN UNDERFRAMING DESIGN

Among cars with all-steel underframes may be noted the following: Connecticut Valley Railway, 1910, 6-in. Z-bar side and end sills and 12-in. channel center sills; Chicago City Railway, 1910, structural material except cast bolsters; Chicago & Joliet Railway, 1911, 8-in. Z-bar side sills, 10-in. channel end sills and 5-in. channel crossings; Reading (Pa.) Transit Company, 1912, steel underframe with convex and concave No. 12 gage sheet steel panels; Stone & Webster design for Jacksonville, 1912, side sills of 5-in. x 3-in. x 3/8-in. angles, 3/16-in. x 15-in. steel plate for lower panel, upper panel of No. 16 gage steel with T-iron posts and carlines; Augusta-Aiken Railway, 1912, steel underframes with 3/16-in. x 18-in. sill plates, reinforced at the top with a 1/2-in. x 3-in. plate and at the bottom with a 2 1/2-in. x 2 1/2-in. x 3/8-in. angle, 10-in. channel end sills, diagonal braces of 3/8-in. x 3-in. steel plates, with channel center stringers and crossings.

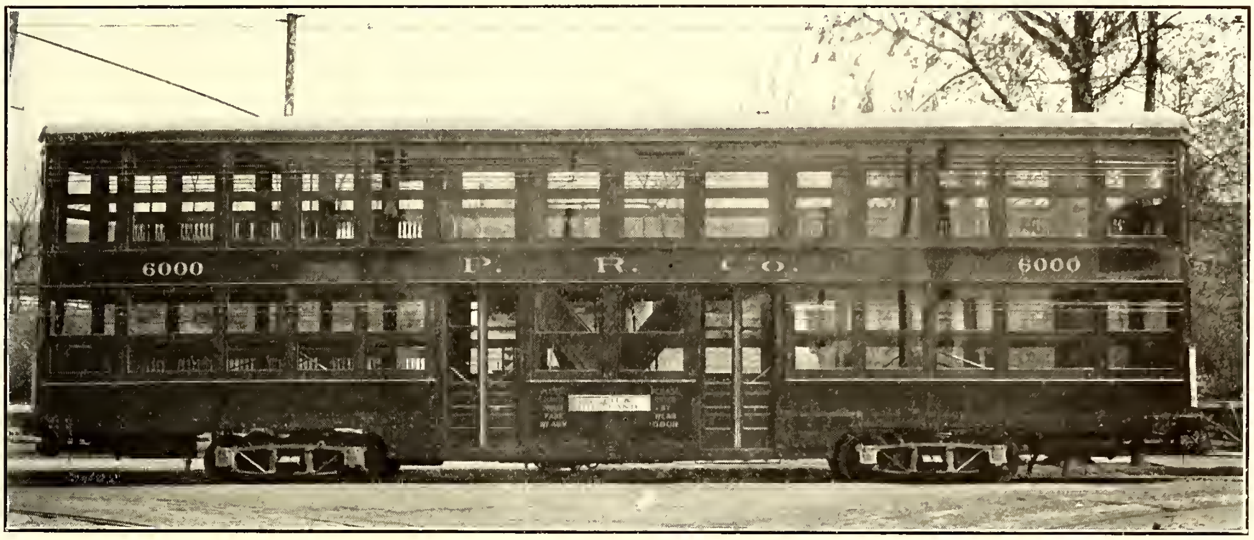
Combinations of wood and steel are still the most popular for the bottom framing of all classes of city cars with drop platforms. Among these the following may be cited as characteristic: Bangor (Me.) Railway & Electric Company, 1910, wooden bottom framing with a 15-in. steel plate on the inside of the sill with the seat ends secured to the sills between the posts directly over the sill plates to give extra inside width; New York State Railways, Rochester, 1910, single-end cars, a 4-in. x 7 3/4-in. continuous yellow-pine side sill extending the full length of the devil-strip side, and reinforced between the vestibule corner posts with 3/8-in. x 15-in. steel plate with the step-entrance side reinforced by a similar plate between the body corner posts, also reinforcement of 3/8-in. x 8-in. plate riveted to the bottom edge of the sill plate and extending from the inside of the end sill at each corner of the car to a point 3 ft. beyond the bolster; Omaha & Council Bluffs Railway, 1911, 5-in. x 7-in. side sills reinforced on the inside with 3/8-in. x 15-in. plate with 2 1/2-in. x 2 1/2-in. x 1/2-in. angles riveted top and bottom to give the general characteristics of a Z-bar and end sills of 5 1/4-in. x 7-in. white oak reinforced with 1/2-in. x 6-in. plate—no inside longitudinal members, as crossings and diagonal braces were designed to resist lateral and corner stresses, while side members were to take vertical load and strains; Rome (Ga.) Street Railway, 1912, wooden underframe but with plate of 1/4-in. steel for the lower side panel extending the full length of the body and brought around to the doorpost at each end, upper panel of No. 14 sheet steel covered with oval iron at the juncture of the sections; Metropolitan Street Railway, Kansas City, Mo., 1912, single-end cars, side sills of yellow pine plated on the outside with 3/16-in. x 32-in. steel plate, end sills and crossings of oak reinforced with steel angles and plates, center platform knees of 4-in. x 3-in. x 3/8-in. angles, platforms supported on step side with 7-in. channels and on the closed side with 3/16-in. x 42-in. plates which form the outside sheathing of the vestibules and are



View of Brooklyn Center-Entrance Car Showing Motorman's Door at Corner of Cab

spliced to the car body to dispense with the usual underframe knee at that point.

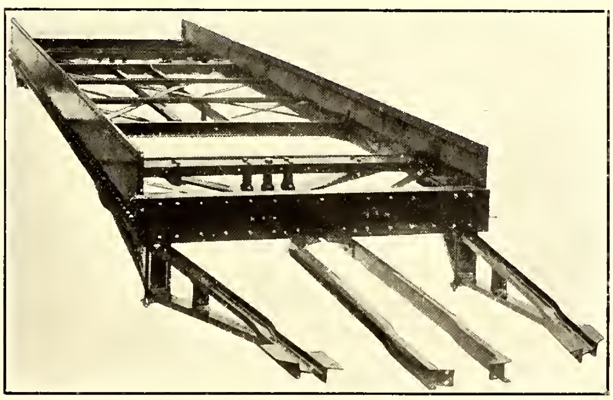
During 1912 the Memphis (Tenn.) Street Railway built some cars with 9-in., 21-lb. I-beam side sills set 9½ in. inside the inner face of malleable-iron side posts which were supported by pocket brackets attached to the main sill. The posts and roof were of wood. This unusual construction was described in the ELECTRIC RAILWAY JOURNAL for March 2, 1912.



Pittsburgh Double-Deck Car with Separate Entrance and Exit Doors

SIDE GIRDER CONSTRUCTION

In a form of all-steel construction which is used largely for center-entrance cars, the weight of the car is taken by the sides acting as girders, while the underframe serves merely to carry the flooring. The side girder construction appears well adapted for low-step center-entrance cars, as it avoids the use of the heavy special under framing which would otherwise be required by the center-well construction; it also insures maximum clearances between the bottom framing and the pavement. The Pittsburgh trailer of 1909 and the Pittsburgh motor car of 1911 are early examples of this construction. In these cars the load transmitted from the bolsters is carried by the side frames. The bottom sill forms the tension member of the plate girder, the belt rail the compression member and the 3/32-in. continuous side sheathing the web. The posts form the vertical stiffening of the web. Heavy reinforcements at the center doors transmit the compressive stress in the belt rails up over the doorway and down to the opposite belt rail. The first group of Pittsburgh cars had wooden posts which were held between light channels, the second had wooden posts held between angles to insure easier removal of damaged plates, while the third group of cars had hollow posts of pressed steel weighing about one-half of the other design. Needle beams are used as floor members.

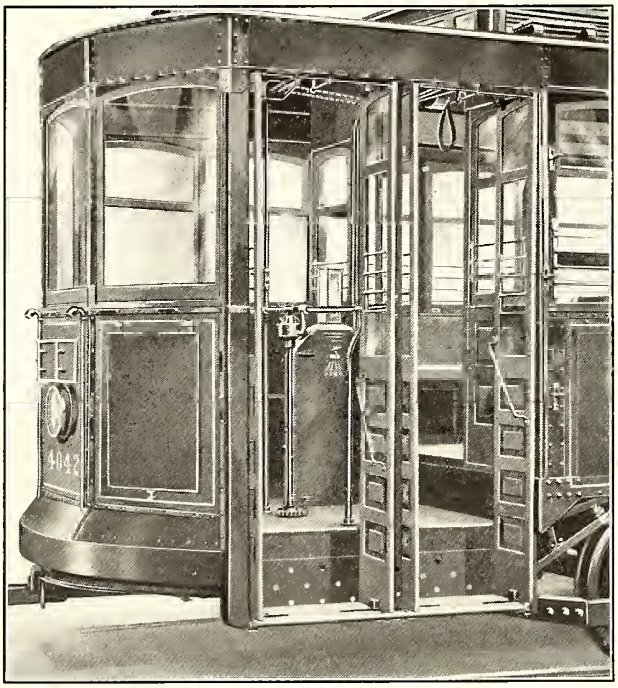


Typical Steel Underframe of Side Girder Construction

The center-entrance cars of the Brooklyn Rapid Transit Company built in 1912 also have a frame of pressed steel. Each side of the car forms a girder consisting of the side plates, belt rail, letterboard and side posts, all of which are riveted to each other, to the side sills and to the carlines. This side girder has a maximum depth of 8 ft. at the center of the car. The sides below the window line and the letterboard sheathing are 3/32 in. except at the ends, where 1/16-in. steel is used. The side sills are angles which are reinforced at the center with other angles. They are riveted to the channel-iron bumpers at the ends to form a continuous line around the car. The cross sills are channel-shaped pressings and the center sills are Z-pressings, both of 3/16-in. plate. Channels are used for the longitudinal floor members.

ROOFS, VENTILATION, INTERIOR FINISH AND FLOORING

A very important change in all types of cars, wood, composite or steel, has been the rapid substitution of the single-arch roof for the monitor and steam coach types within the last three years. To-day the arch roof is the rule and the monitor roof the exception in newly constructed cars. As early as April, 1891, an article in the STREET RAILWAY JOURNAL pointed out the disadvantages of the monitor design. Nevertheless, street railway operators clung so tenaciously to the monitor roof that it continued in use even on open cars where, of course, ventilation was not a factor. The real drawback of the single-arch roof, namely, adequate ventilation, has been met by a large variety of natural, exhaust and forced



Platform Steps Inclosed by Doors, Pittsburgh Railways

draft ventilators. In some installations the intakes are located near the floor line so that in winter the incoming air will be warmed by the adjacent electric heaters. In others the intakes have been placed higher in order to get cleaner air, and in still others forced draft is furnished by a blower placed over a coal stove or in the hood of the car. The fancied objection to the arch roof was that of appearance, but familiarity with both types generally leads to the acknowledgment that a simple natural curve is more pleasing to the eye than the unnatural combinations of the monitor. Among the positive advantages of the single-arch roof are greater headroom, stronger yet lighter construction and availability for larger window areas. Thus in one car the single arch permits the windows to be 5 in. higher, while in a car only 30 ft. 1 in. over all this design effected a saving of 400 lb. in weight as compared with a monitor roof.

Almost coincident with the development of the arch roof has been the use of composition and metal linings for ceilings and other interior finish. The old headlinings were usually confined to birch, maple, cherry, mahogany or oak veneer. The newer linings are fireproof and give no trouble from warping or shrinkage. While they can be made to match any finish desired they are most serviceable when treated with a light-colored enamel, which gives the car a more cheerful appearance and materially improves the lighting. The heat-insulating qualities of some composition materials make them desirable for the inside lining of side sheathing, posts, etc. In some instances the entire roof has been made of such compositions, the inner side being tinted or painted as a ceiling and the outer side being covered with canvas.

Another innovation in car construction is the use of monolithic floors, which are fireproof, durable and easy to clean. The flooring is spread as a plain or reinforced cement on a base of galvanized sheet iron and special shapes. It is usually inclined toward the center to facilitate drainage, and occasionally the thickness is increased at places of maximum wear. For cars with ramps the composition may include a gritty material like carborundum so that the entire floor is practically an anti-slip tread but not sufficiently so to impede passenger movement. These floors lend themselves readily to ramp construction.

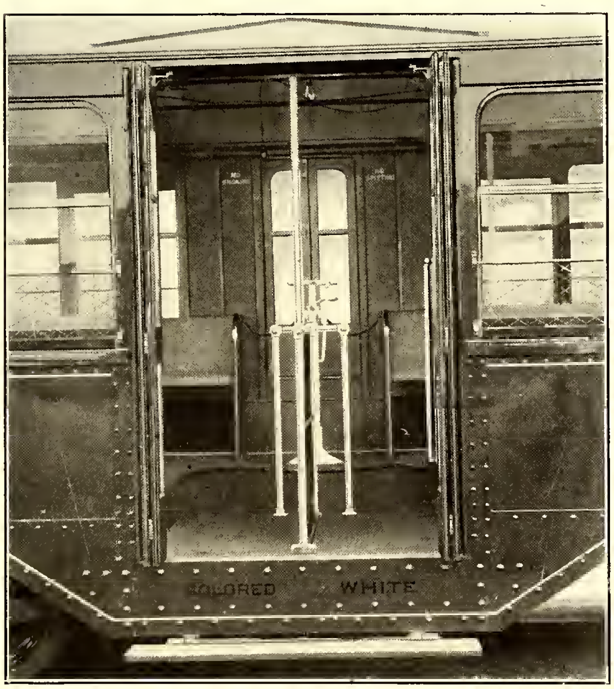
RAILINGS AND STEPS

In 1903 the most common length of the platforms of double-end city cars was, curiously enough, the same as the standard track gage, namely, 4 ft. 8½ in. In the Middle West, however, where many single-end cars were operated, the rear platforms were as long as 7 ft. These platforms were provided with railings of the Detroit design, which did not separate incoming passengers but simply formed a "pen" for smokers. The end body doors of most cars were either of the centered double-sliding type or of the offset accelerator design. Vestibules had come into use for several years past, but most of them were inclosed on one side only, and in mild climates gates were employed instead. No apparatus controlling the movement of passengers was used, except that on the single-ended cars of the Twin City Rapid Transit Company the gate on the rear platform was under the control of the motorman. Although this gate had been in use since 1895, its principle appears to have been adopted

Interior View of Seattle Car, Showing Elimination of Bulkhead

by a few companies only, as at Des Moines, where a wooden gate was employed for the same purpose.

The simple Detroit railing was succeeded by the Montreal double railing on those systems where it was thought desirable to leave space for smokers in addition to separate aisles for entering and departing passengers. The railing which incloses the smokers is usually curved inward against the vestibule posts so that no one can enter or leave without passing the conductor. These railings show an unlimited variety in curvature, depending upon the operating company's idea of the best location for the conductor. The prepayment railing of the Detroit United Railway is of straight pipe almost entirely and includes within the center line of the car a three-sided inclosure for the conductor. On some systems the railing extends from the intermediate door posts or stanchions of the vestibule to a similar supporting point between the body end doors. Several companies have found, however, that a very short railing will serve to divide effectively the two currents of travel. For example, the railing of the Third Avenue Railway, New York, does not extend all the way to the bulkhead. On single-end cars the railings are fixed, but on double-end cars it is customary to raise them out of the way when the platform changes from front to rear and vice versa. On many cars a short railing is also used to protect the motorman from jostling by departing passengers. The platform railing as a whole is undergoing simplification mainly because the "safe" type stationary fare boxes, which were quite common at the beginning of the prepayment period, have been largely abandoned in favor of small portable boxes. In the pay-within type of prepayment cars railings are hardly necessary because the bulkhead doors are omitted to enable the conductor and his stand to form the dividing line between incoming and



Drop-Side Entrance for Birmingham Car, Showing Division for White and Colored Passengers

outgoing passengers. Most prepayment platforms are provided with grab handles and vertical stanchions both to insure convenience to passengers while entering and alighting and to afford means of support should the car be started suddenly while passengers are on the platform.

Among the first city cars in which provision was made for the simultaneous operation of doors and steps were those built in 1905 for the East Boston tunnel service of the Boston Elevated Railway. As these cars were built with flush platforms, a double step was used. When

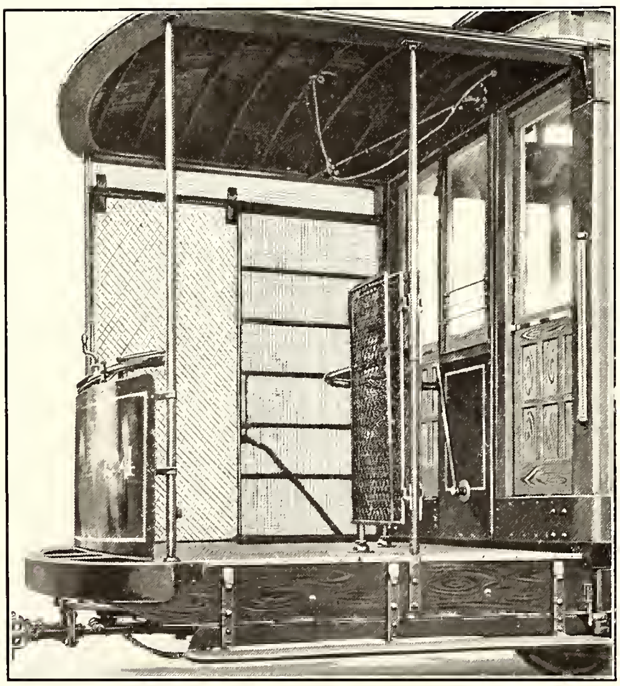
Inclosure for Smokers on Topeka Car Platforms

the door was closed pneumatically the lower step folded against the upper one. Toward the end of the same year the Chicago City Railway installed some cars with a sliding step. Many other mechanisms have since been devised in connection with door and step operation, but in most cases the step is of the folding type and a delay movement in the operating levers is sometimes provided so that the door does not open far enough to permit passage until the step is horizontal. In several cars furnished to the Omaha & Council Bluffs Railway and other companies during 1911 the steps did not fold, but when the doors were closed their upper surfaces were covered by sloping projections hinged to the doors. Another variation is found in the cars of the Pittsburgh Railways, where the steps are within the line of the car body so that they are completely concealed as soon as the doors are closed. The subject of steps is, of course, intimately connected with that of low entrance height. In a few cases this end has been attained by the use of a double step like that of the 1905 Boston car, which, however, had no platform, but the most popular method is likely to be the construction of sloped floors or ramps. The ramp used in the near-side car is a very moderate one and is intended only to reduce the height between the floor and pavement from 39¾ in. to 36½ in. In some center-entrance cars the low step is obtained by means of a ramp between the depressed platform and the bolster line at each end. In the stepless car of the New York Railways a well is formed at the ends by dropping the floor between the wheels. The Metropolitan Railway Company, Kansas City, uses a platform runway which rises 12 in. between the floor at the entrance door and the main floor of the car.

PLATFORM ARRANGEMENT

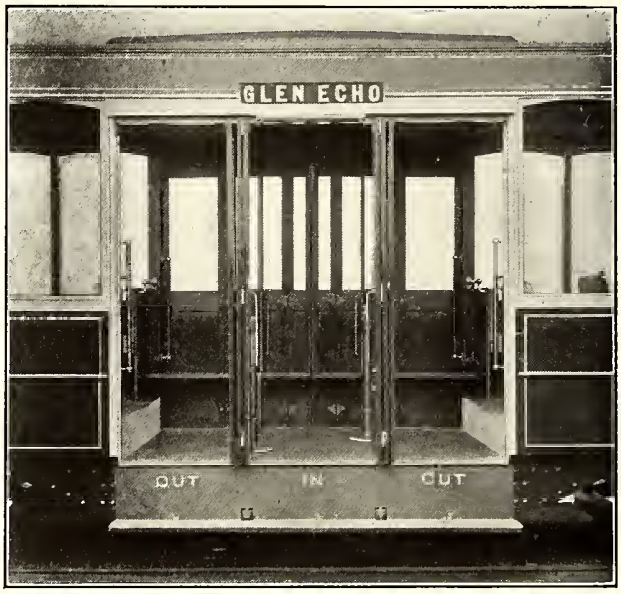
The first prepayment cars were characterized by the great length of their platforms. Thus the pioneer cars at Montreal had 7-ft. platforms which were intended to accommodate thirty passengers at one time. The pressed steel car built for Montreal in 1907 had a platform measuring actually 9 ft. $4\frac{3}{8}$ in. inside length. These excessive lengths were due in part to the desire to accommodate smokers, but their principal purpose was to avoid congestion on the platform when the passengers were paying fare. The same motive was responsible for the 6-ft. 1-in. platforms of the Chicago Railways in 1908 and the 7-ft. $5\frac{1}{2}$-in. platform of New York built during the same year, although both cars were for double-end operation. As the public became better acquainted with prepayment, however, operating men took a saner view of the platform situation. As a result, most of the cars of recent construction have been provided with shorter platforms. In fact, on some systems, like the Third Avenue Railway, New York, the unchanged 4-ft. 6-in. platforms of cars converted for prepayment are used with entire satisfaction.

Motorman's Cab in Single-End Spokane Car



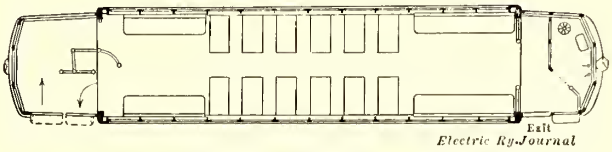
Screened and Hinged Gates Used in Wichita

Diffidence with regard to the public reception of the prepayment system led also to the use in some designs of more doors than necessary, and it is a surprising fact that the original Montreal single-end cars are among the simplest prepayment cars in use. Despite the cold winters in that city the rear platform is entirely open on the operating side, and no body doors are provided at the front. The step at the rear platform is fixed, but a folding step is used with the sliding exit door of the inclosed front vestibule. This front door and step arrangement is the one characteristic now common to practically all prepayment cars except the near-side type. In Quebec, where the winters are even more severe than in Montreal, the rear platform is also open on one side. The success of this construction shows that a fully inclosed rear vestibule is unnecessary with single-end cars, unless body doors are omitted.



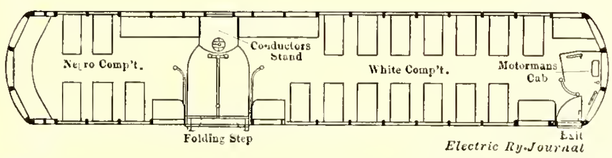
Folding Doors of Washington Center-Entrance Car

In order to save weight and expense, the cars built for the United Railways of St. Louis in 1909 were not fully vestibuled at the rear, but a small cab was furnished to protect the conductor. In the Rochester cars of 1910 protection was furnished to the conductor by inclosing the exit at the platform step with a single swing door. The rear platform of the Columbus (Ohio) Railway & Light Company's cars of 1910 was provided with exit and entrance doors which were hinged to a center post on the side of the vestibule, while another post on the platforms formed a stop for the doors and a terminal for the dividing rail. In the Wichita cars of 1911 the



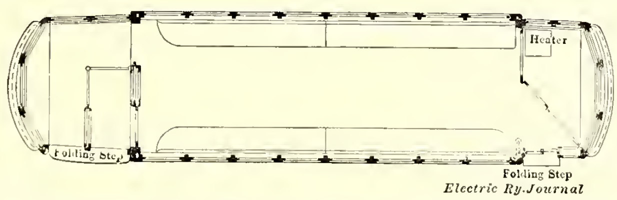
Detroit Single-End Car with Rail Inclosure for Conductor and Partly Inclosed Motorman's Cab

sliding door at the front platform differed from the usual arrangement in being placed next to the bulkhead. This location saves a step when passengers leave the car, but it obliges the motorman to turn his head when watching the departing passenger. The rear platform of the Wichita car had a conductor's cab only, instead of the full vestibule. The cab extended from the vestibule step to the sliding entrance door of the body, being so placed that two of its sides were formed by the body exit door and a two-section vestibuled folding door under the control of the conductor. In 1911 the Washington Water Power Company purchased for operation in Spokane some 51-ft.



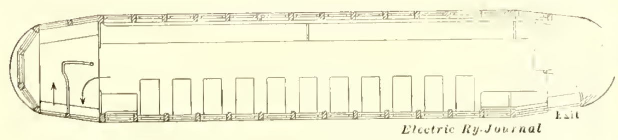
Side-Entrance Car for Birmingham with Compartments for Two Classes of Passengers

cars, the 6-ft. 5¾-in. rear platform of which was novel in that the exit and entrance doors at the vestibule were arranged to slide into an intermediate pocket. An emergency exit door was also furnished on the opposite side of the vestibule. Provision for changes in weather is afforded by the practice of the Illinois Traction System, which uses doors and gates according to the season on some of its cars. In the car developed in 1910 by the Stone & Webster Engineering Corporation for Jacksonville, Fla., and other Southern properties the rear bulkhead is moved in from the end sill far enough to give standing room for the conductor on an open platform.



Single-End Car for Saginaw, Mich., without Front Bulkheads but with Motorman's Cab

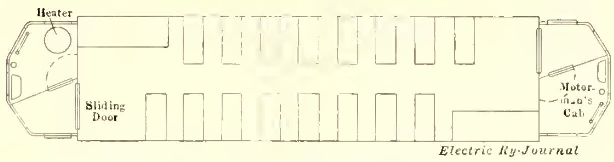
The most recent form of single-end cars is the near-side design in which practically all operation is at the front, although a small door at the rear may be used if necessary. This car was introduced in Buffalo early in 1911 and has since been adopted in Philadelphia, Chicago and several other cities where the near-side stop is used. As in other prepayment cars the folding vestibule doors and steps operate together. No body doors are used. The conductor is stationed either on the platform or at a corner just within the bulkhead line at one side.



Pittsburgh Single-End Car without Bulkheads, Arranged with Longitudinal and Cross Seats

ONE-MAN CARS

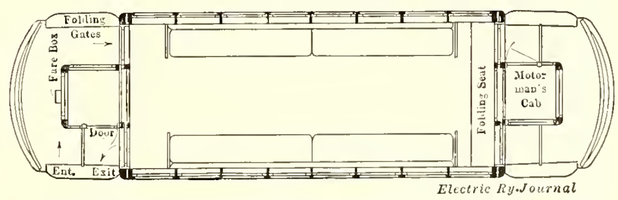
Modern one-man cars are necessarily operated on the near-side principle, because all passenger movement is at the front, whereas in the bob-tail horse car the passenger entered at the rear through a door which was under the control of the driver. In the one-man electric cars of to-day it is customary to keep the rear doors or gates locked, except in emergencies. These cars are built both double-end and single-end. Among the smaller cities where one-man cars are now used are the following: Brunswick, Ga.; Missoula, Mont.; Waco, Tex.; Muskogee, Okla.; Selma, Ala.; Sheridan, Wyo., and Freeport, Ill. How-



Plan of Connecticut Valley Easy-Access Cars with Cab at Each End

ever, the experience of the International Railway Company, Buffalo, with one-man cars at Lockport has shown that there is also a field for this car on the weak traffic lines of large systems. A summary of the one-man car situation from an operating standpoint was published in the ELECTRIC RAILWAY JOURNAL for March 29, 1913. The small storage battery cars which are run in New York could readily be handled by one man on some lines during certain hours, but an old municipal ordinance which has never been repealed forbids the operation of cars with less than two men.

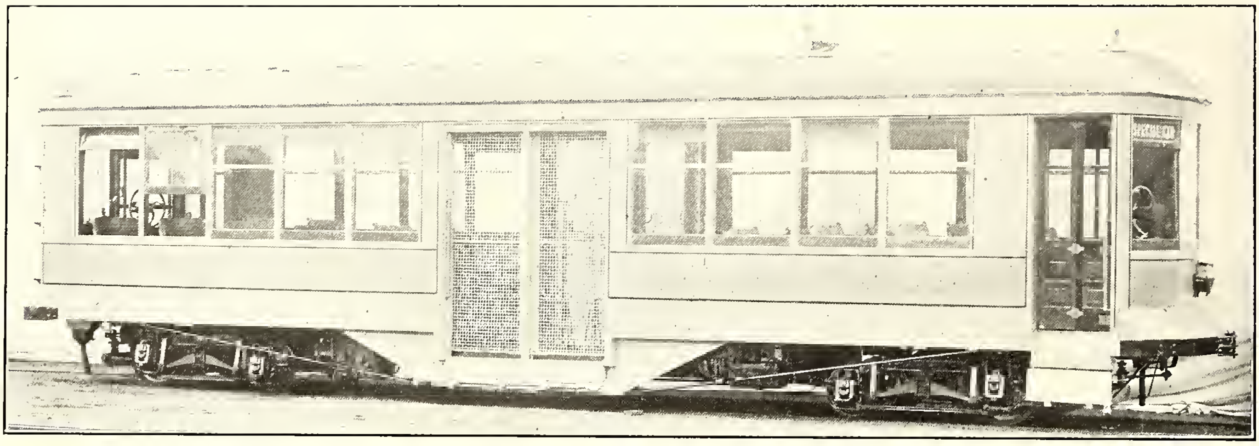
The one-man car used by the City & Suburban Rail-



Muskogee Double-End Car Suitable for Operation by Either One Man or Two Men

way, Brunswick, Ga., since 1910 has a folding exit and entrance gate at the front platform with a similar locked gate at the rear. The motorman-conductor of these cars is provided with a portable cash box, and at Waco, Tex., he has a transfer-issuing machine. The cars of the

Muskogee (Okla.) Traction Company, built in 1910, have no vestibules, but a cab is placed in the center of the platform against each bulkhead. The cab is only 3 ft. square and is furnished with a folding entrance door at the side. In the Freeport (Ill.) Railway & Light Company's cars, built in 1912, the step openings at both sides of the platforms are inclosed with two-part folding doors, one part being hinged to the corner post of the car body and the other hinged to the corner post of the vestibule. Both doors are operated together by a lever within convenient reach of the motorman-conductor. Inclined sheet-metal guards are secured to the lower part of the doors to cover the steps when the doors are closed. A sliding entrance door and a hinged exit door are used in the bulkheads.



Santa Barbara Center-Entrance Car with Hinged Gates in Place of Doors

DOOR ARRANGEMENT

The door systems of modern cars show a great many variations, but a sliding exit door is almost invariably used in the front vestibule. The body doors comprise either a sliding entrance and swinging exit door, a pair of doors sliding into a central pocket in the bulkhead or double doors sliding into end pockets. Sometimes the doors are separated by a post, but in practice it has been found that such posts are a hindrance rather than a help, as the dividing rail is sufficient. In the pay-within car introduced in Philadelphia in 1908 the body has no bulkhead and the vestibules are therefore fully inclosed either with folding or sliding doors. This arrangement was adopted to avoid long platforms because the conductor stays within the body of the car. The vestibule doors at the rear and front are under the control of the conductor and motorman respectively.

If double-ended cars are provided with body doors the use of a fully inclosed vestibule is unnecessary except where severe weather conditions prevail. Where vestibule doors are used on such cars they are ordinarily arranged to fold back to back in the middle of the vestibule, or each half folds against the bulkhead and vestibule post respectively. On the Public Service Railway gates instead of doors are used to control the entrance and exit of passengers.

Various cab and railing constructions are in vogue on double-ended cars to isolate the motorman from the passengers. One of the earliest folding cabs on city cars was that of the easy-access car built since 1908 for the United Traction Company of Albany, the Boston Elevated Railway and other Eastern companies. In this type a diagonal partition extends from the center line of the car body at the bulkhead to the front of the vestibule. Many other forms of cabs have been devised. It is questionable, however, whether it is necessary to build such partitions on drop-platform cars when a simple railing and curtain will serve the same end at a much lower cost and at a great saving in weight. Studies of the dimensions of some cabs indicate furthermore that no provision has been made in them to leave room for a motorman instructor.

Operating Platform, Waco (Tex.) One-Man Cars

Before the subject of doors is left, note should be made of the tendency to use both wired and clear glass for both upper and lower panels to enable the motorman and conductor to keep better watch on the passengers at the steps. Such doors are now used at Montreal, Boston, Milwaukee, Rochester, Syracuse and many other cities. Doubtless clear glass would be preferred uni-

Operating Cab on Open Platform, Muskogee One-Man Car

versally if it were not for its greater liability to breakage.

SPECIAL TYPE CARS

As previously noted, the Ohio and California type cars

Pocket for Sliding Vestibule Doors on Spokane Cars

had been in use for a number of years previous to 1903, but no improvements of any importance had been made in them until lately, when a number of companies on the Pacific Coast have begun to adopt the California car for prepayment operation. Both of these designs, in fact, have been found well suited for this purpose and have

Vestibule Doors with All Panels Glazed, Cincinnati Traction Company

been equipped with the usual combinations of doors, folding steps, etc.

A much more important development is the rejuvenation of the side-entrance car. This car has long been used in Denver and in some other Western cities, but with the exception of the side-entrance car built for Des Moines, in 1903, and the double-entrance car for Portland, Ore., in 1904, little new work was done with this type until 1911. In that year arch-roof trail cars were built for the Emigration Canyon Railway, Salt Lake City, with a center opening 8 ft. 2 in. wide and some center-entrance cars were put in use on the Renton line in Seattle, but with the Pittsburgh trailer of 1911 and the New York stepless car of 1912, a new era was opened for the center-entrance car. Center-entrance trail cars of new design are now used not only in Pittsburgh but in Cleveland, St. Louis and other cities.

The most radical feature of the Pittsburgh center-entrance car was the low floor obtained by the use of 22-in. wheels. Since it was built the railway company has designed a small high-speed motor which permits the same wheels to be used under a center-entrance motor car. In the New York stepless design the feature indicated by its name is obtained by the use of a central well, ramps and end wells, as previously noted. The Brooklyn center-entrance car of 1912 is less radical in design than the New York car, a considerable reduction in height being obtained by the use of a ramp between the well and the bolster line and wheels of 28-in. diameter instead of 33-in. The Washington car of 1912 is the most conservative of all the center-entrance designs, as it has no ramp or power-operated doors. Among other cities where center-entrance motor cars of recent design are used are San Diego, Cal.; Santa Barbara, Cal.; Butte, Mont.; Montreal, Que., and Birmingham, Ala. In the Montreal and Birmingham cars the opening is not at the center so that two compartments of unequal size are furnished. In the Montreal car, which is used for suburban service, the purpose is to provide a smoking compartment and in the Birmingham car to furnish separate accommodations for white and colored passengers. The largest center-door opening for a motor car, namely, 6 ft. 6 in., is used by the Brooklyn Rapid Transit Company in order to secure a 34-in. entrance aisle and two 22-in. exit aisles. The Brooklyn company has 101 cars of this type in operation, and the New York Railways has in service or on order 176 stepless cars.

The double-deck car, which was temporarily revived in 1906 by the Twin City Rapid Transit Company for its lake excursion service, has been brought forward again during the past two years in Pittsburgh, New York and Washington. These double-deck cars are developed directly from the latest single-deck cars of the companies named. The Pittsburgh Railways, after one year's experience, has ordered five cars more, but in New York and Washington only one car each is operated at present. These double-deck cars represent an immense improvement over the primitive types so far as loading and unloading ability are concerned, but as these features have also been improved in single-deck cars, the principal field for the modern use of the double-deck car seems to lie in its ability to handle a larger load at shops and other points where great masses of passengers must be accommodated in the shortest possible time rather than on lines with very short headways.

Double-Deck Car of the Stepless Type, New York Railways

MISCELLANEOUS IMPROVEMENTS

One of the accompaniments of the prepayment system has been the closer attention paid to seating arrangement because the provision of exit and entrance aisles has made it necessary to improve clearances wherever this is possible.

The most common seating arrangement is the use of transverse seats in the middle of the car and longitudinal seats opposite the doors. A great variety of folding seats is in use both in the car body and on the platforms to avoid idle seating space. Seat materials are much the same as in former years except that pressed steel pedestals have been introduced during the past two or three years. In the Rochester cars of 1913 additional clearance is secured by supporting the seats at one end on shelves under the windows.

Several companies have shown a tendency to eliminate the unsanitary leather strap either by using vertical rods or by covering the lower part of the strap with a sanitary sleeving. In fact, the desirability of improved sanitation has been generally recognized by the designers and manufacturers of all recent cars.

On account of the location of the conductor on the platform the use of push buttons operated either from a battery or from the trolley through resistances has become universal on prepayment cars. Push buttons were introduced many years ago, but in some instances they were abandoned owing to the vandalism of passengers. Several center-entrance and other cars built during the last year or two are also provided with signal circuits which either warn or prevent the motorman from starting the car until all doors are closed.

Another important step along electrical lines in car-body equipment is the use of tungsten lamps. The prepayment system has not in itself affected car illumination to any extent except that more lamps are placed in the vestibule and in several instances one or more lamps are installed over the steps. A favorite plan where several lamps are used in this location is to place each step lamp on a separate circuit. In this way if any single lamp circuit is interrupted from any cause the step is not left in darkness.

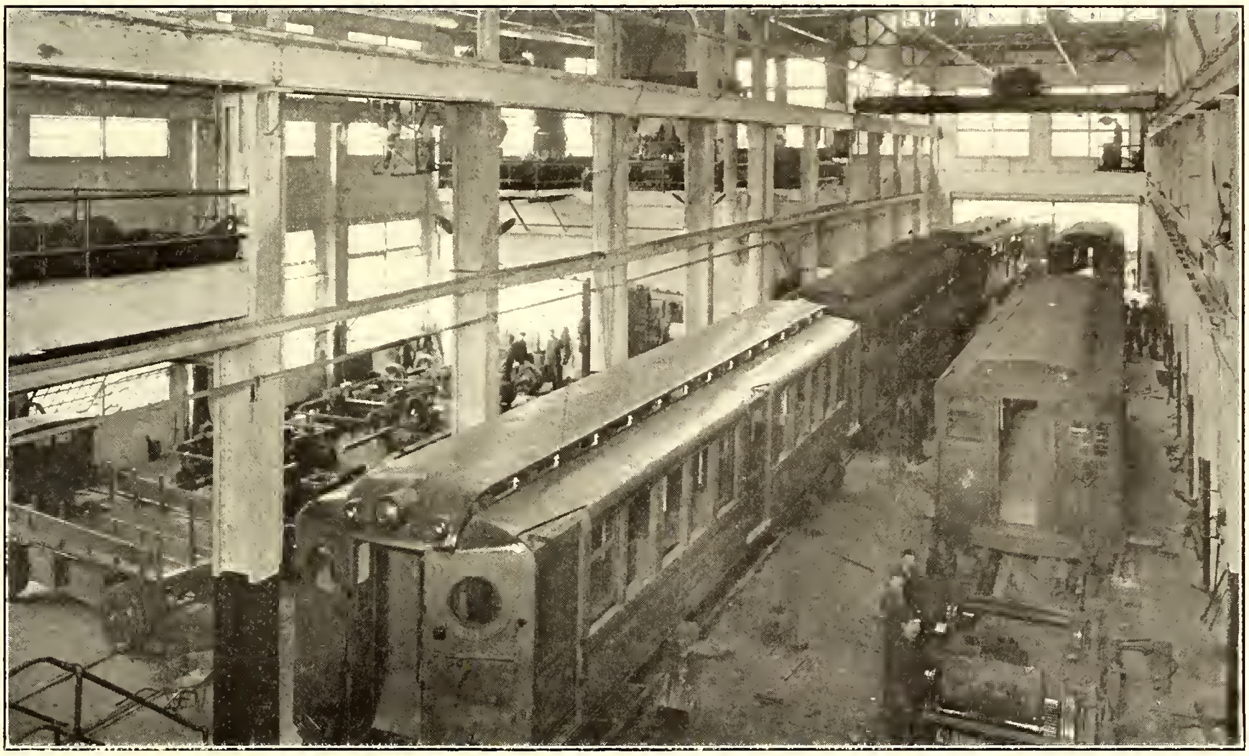
REPAIR SHOP DESIGN AND OPERATION

IN the general arrangements of the latest repair shops to be built by electric railways the most noticeable feature is compactness. This quality obtains in the design regardless of the plan of operation, and in every one of five shops which have been built within the last two years and which may be classed as representative it appears prominently, notwithstanding wide divergences which are displayed in other respects.

REPAIR SHOPS FOR STEEL CARS

Of these five shops two are intended for steel or semi-steel cars, and this fact is shown in the accompanying diagrammatic layouts by the relatively small space devoted to car-body repairs. The shop of the New York, Westchester & Boston Railway, a New York suburban line, possesses special interest because it is the second shop for all-steel equipment to be built within a short period of time. In the cars for this line, in fact, there is no wood of any description except for the seat arms and the sash, and in consequence the usual carpenter shop and wood mill are eliminated completely. In addition, it is expected that car-body repairs, aside from the possibility of wrecks, will practically never be needed, so that the space usually provided for car-body repairs is also eliminated. This condition, in turn, has very naturally developed the procedure of renewing the damaged or worn car parts instead of repairing them in place. As a result the cars are never taken to the shop for general overhauling but are ready for service practically 100 per cent of the time. As the shop has been in operation for more than one year, sufficient experience has been obtained with this scheme to demonstrate its perfect practicability, and the most satisfactory results are reported by the operating officials.

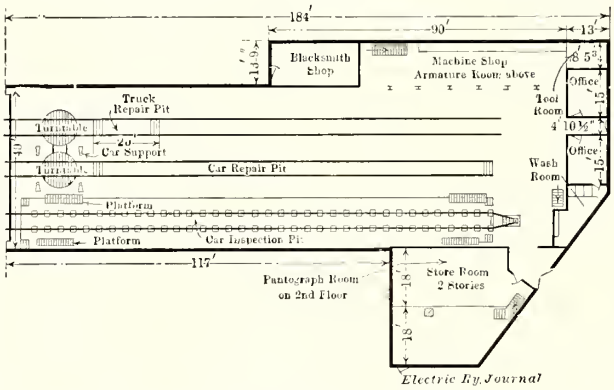
From the diagrammatic layout of the shop it will be noted that no provision has been made for painting. The paint shop was left out in this case because at the time the shop was built all of the cars were new and in consequence would not need painting for at least one year. At present the use of the baked enamel process for painting, which will be later referred to, is under consideration, as the paint shop may thus be replaced by a kiln or oven only large enough to hold one car. At the same time the cars may be painted complete in two or three days instead of having to be held for a period five or six times as long.



Truck Shop for All-Steel Cars, Hudson & Manhattan Railroad

The other recently built steel-car repair shop to be considered is that of the Hamburg Rapid Transit System in Germany, which was designed to serve cars with steel frames and side paneling but with wooden floors, seats and roofs. The arrangement of departments has been characterized as an exceptionally good one for reducing the lost motion often involved in the handling of repair parts, and for a European shop an unusual number of labor-saving devices in the form of cranes and hoists have been installed.

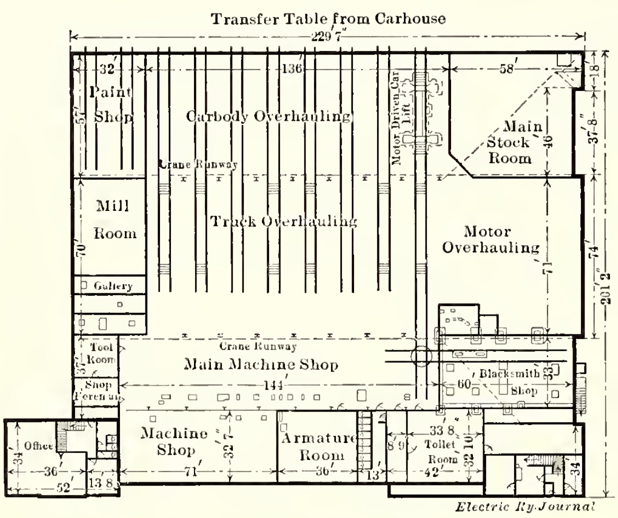
In this case all departments have been housed under the same roof, although this involved a building about 200 ft. x 230 ft. in outside dimensions and necessitated special provisions for roof lighting in the central portions on account of the distance from the windows in the side



Steel Car Repair Shop, New York, Westchester & Boston Railway

walls. This feature is of obvious advantage not only in providing a compact arrangement but also in making shop operations entirely independent of weather conditions, a serious matter in some localities.

The principle of this arrangement is somewhat similar to several which have been used in this country, the cars being lifted by a car hoist for the removal of the trucks and then being moved by a transfer table to adjoining pits for car-body repairs. The trucks are then passed on into a truck shop just back of the car-body repair shop, and the repair parts are taken to a machine shop in back of the truck shop and having the blacksmith shop at one side. Miscellaneous departments are located along the walls around these three main shop spaces. The



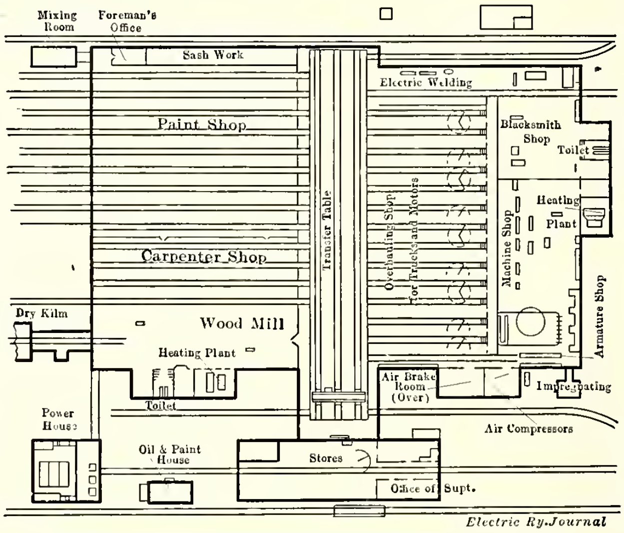
Repair Shops of Hamburg Rapid Transit System

portions which are used for blowing out equipment with compressed air and for the dipping of trucks and motor shells in lye vats are completely inclosed, thus avoiding discomfort to employees and maintaining cleanliness in the main shops.

REPRESENTATIVE SHOPS FOR SURFACE CARS

The repair shop at Montreal, Canada, which has only just been completed, is another example of housing all departments under one roof, the object being obviously to offset the severe winters characteristic of the Canadian climate. This building is even larger than the Hamburg shop, having approximate dimensions of 425 ft. x 285 ft. for the main building, not including additions. The leading feature of the design is the covered transfer table in the middle of the building. This separates the departments handling the carpentry work or car-body repairs from those devoted to the iron-working which is involved in truck repairs. Cars and trucks are handled on transverse tracks, which on the car-body side extend through the building wall to the yard and on the truck shop side extend only part way across the building and leave a wide space for machine tools and for floor work.

It is probable that in no other shop has so much attention been given to the effect of temperature on paint



Repair Shops of the Montreal Tramway Company

and varnish as in that at Montreal. The space inclosing the transfer table is thoroughly heated so that freshly coated cars can be handled to and fro, absolutely protected against ruinous variations in temperature. In the heating and ventilating system of the paint shop, a water trap has been installed in the outgoing air duct to catch any dust which may have been taken in by the fans. In the iron-working portion of the building the natural and artificial air currents are so regulated that the down-draft forges in the blacksmith section keep the shops free from smoke and noxious gases.

The new Detroit shops, of which about one-half of the complete layout is constructed at the present time, are, in all probability, the most compact shops of the separate building type which have yet been built. The design is characterized by a liberal installation of transfer tables, each end of each of the four buildings which will constitute the final layout being served by a separate table. In addition, these tables are unique in being a revival of the "flush" type, no pits being installed to hamper communication between the various buildings.

The arrangement of departments is unusual. The iron-working shops, including blacksmith, machine and truck departments, are housed under one roof, and the car-body repair departments, the wood mill, carpenter shop and lumber storage are in another building. The paint shop, however, is in still another building, separated from the first two by a wide alleyway, and it has no immediate connection with the carpenter shop, either by transfer table or by a direct track. In consequence, car bodies have to go through a comparatively elaborate switching operation when moved between the carpenter shop and the paint shop.

The new shops of the Portland (Ore.) Railway Light & Power Company were completed but a few months ago and represent in their equipment a number of novel features. However, the general arrangement of the buildings and departments follows, to a large degree, a form of layout which has been sometimes used in the past, namely, the division into three main buildings—a paint shop, a carpenter shop and wood mill, and a truck and iron-working shop—all of the buildings having transverse tracks and being separated from each other by transfer tables. The storehouse is, however, located some 300 ft. away from the nearest main building, so that this department lacks the mutual convenience of access possessed by the others.

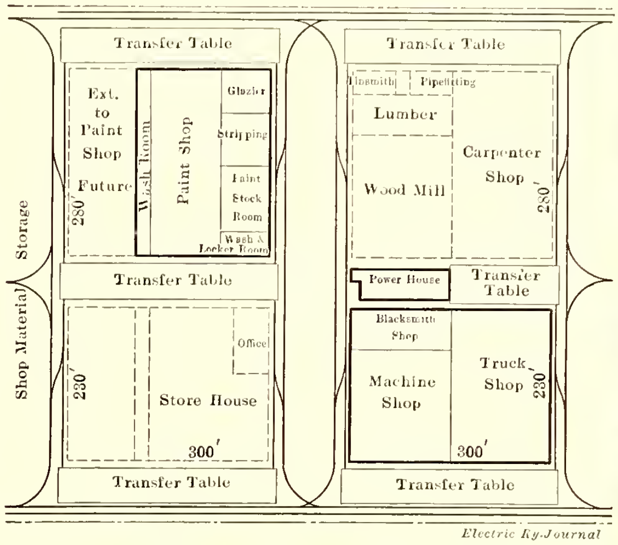
UTILIZING OLD SHOPS

Among the older shops, especially in the case of those in large cities, the consolidation of properties has in many cases placed the car equipment department in possession of several shops of which none is really suitable for all-around maintenance work on modern apparatus. The ideal solution for such a problem would be, of course, to erect one new building as a successor to all of the old ones, but as this is not always practicable another way out of the difficulty has recently been widely adopted. This is to single out each shop for a particular class of work, and the practice has proved so successful on one road that the actual shop area is less to-day than it was ten years ago. Thus air brakes are handled at one place, curtains at a second, wheels and axles at a third, etc. When the several shops on this road were complete in themselves there was much needless duplication of machinery, waste in supplies and unskilfulness in operation. The specialized shop, on the other hand, has insured more uniform use of all equipment, has avoided the necessity of carrying excessive stores, and has made it profitable to employ specialists for departments which would otherwise be too small for such direction.

One great economy which follows from the practice is that all old material, no matter what its condition, must be sent to the shop for the inspection of a responsible shop official. This eliminates the careless disposal or wilful mishandling of such material by carhouse men, who naturally prefer brand-new to refurbished supplies. Shop specialization does not mean that a car which is in for overhaul or repairs must be taken to each plant in turn. On the contrary, a great deal of mileage is saved because the replacing equipment is carried to each car maintenance center by a few supply cars, on the principle that it is cheaper to bring the parts to the cars than the cars to the parts.

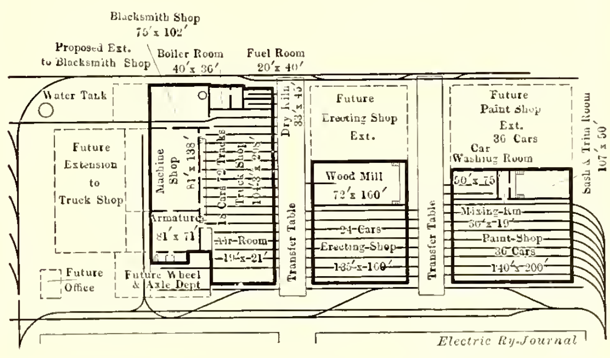
REPAIR SHOP OPERATION

It is obvious from a consideration of the layouts of recently built repair shops that existing practice in shop



Repair Shops of Detroit United Railway

design is by no means approaching a standard and that a very distinct endeavor is being made at the present time to secure the advantages which accompany improved methods of arranging shop buildings. The same statement may be made in regard to repair shop operation, as a really large number of new and improved methods of doing work are being constantly introduced. That there has been room for improvement in electric railway repair shop practice must be generally admitted, and the recent agitation with regard to the possibility of introducing any of the systems of "scientific management" or efficiency



Repair Shops of Portland Railway & Light Company

engineering is evidence of a desire to eliminate wasteful and inefficient processes.

EFFICIENCY ENGINEERING

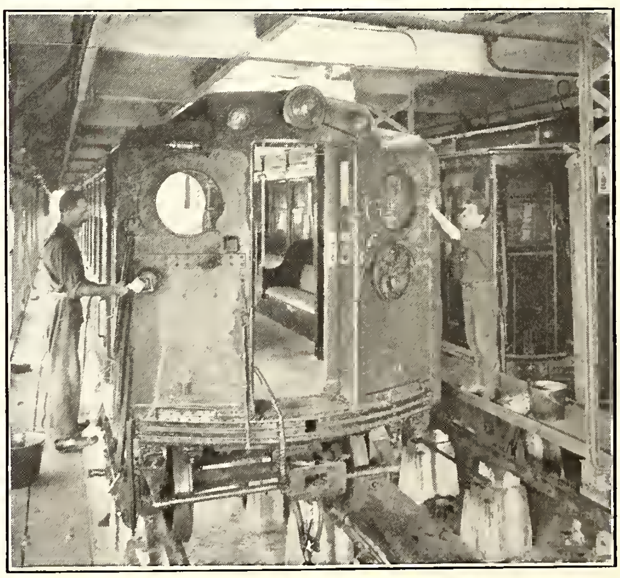
However, few of the methods peculiar to the modern efficiency engineer have actually been introduced in electric railway repair shop practice. One reason for this is undoubtedly the fact that the operations involved in the maintenance of electric railway cars are in no sense comparable to manufacturing processes, and in consequence there does not exist the exact daily routine of operations which is so necessary if a comprehensive analysis of each workman's movements is to be made. Another reason, possibly of more influence than the foregoing, is the bitter controversy which has arisen within the ranks of the efficiency engineers themselves regarding not only the relative importance but even the actual value of some of the methods applied in some of the more elaborate systems of efficiency engineering.

Department in East New York Shop, Brooklyn Rapid Transit System, Where All Seat Repairs Are Made

Most of this controversy has arisen through attempts to confine the field of efficiency engineering largely to methods whereby the individual output of the workman is greatly increased, such as are generally accompanied by special systems of payment for rewarding skilful or industrious employees, and to a large extent the belief that scientific management is thus limited has come to be the understanding of manufacturers and shop officials generally. Judged by the weight of opposition among efficiency engineers, this impression appears to be incorrect, and, indeed, it now seems to be the consensus of opinion that a very highly systematized method of operation together with a complicated scheme of remuneration may actually prove detrimental rather than advantageous to the over-all cost of manufacturing.

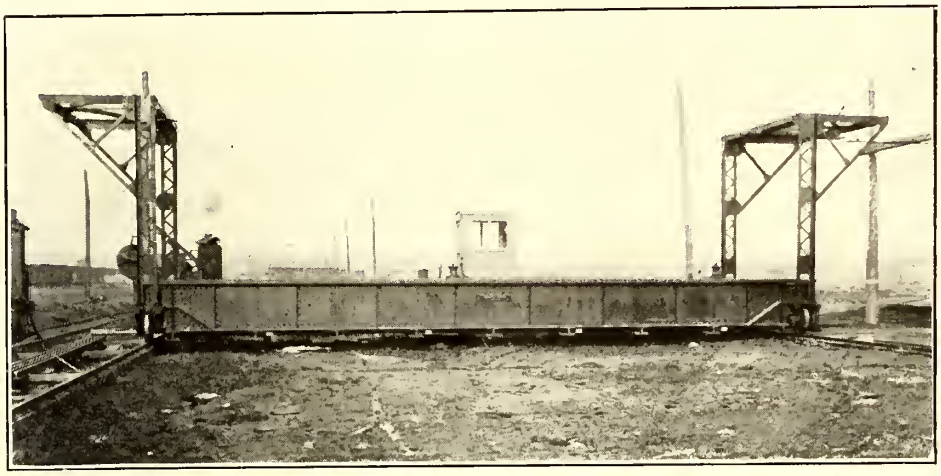
Indeed, it may be safely said that where work is as variable in character as it is in an electric railway shop any success attained will have to depend largely upon the personal element, and not, as in the theoretically ideal scientific management, upon a rigid system which lays down in advance rules for the guidance of every employee in every operation and under every circumstance. This does not mean that none of the operations in an electric railway shop is capable of being benefited by systematization. Nor does it mean that operations wasteful of time and material cannot be discovered and eliminated. On the contrary, several electric railways are making detailed studies along these lines, although in no case apparently has any outside firm of specialists been employed.

Thus, on the Boston Elevated Railway the improvements in shop operation, as outlined at the last A. E. R. A. convention, have been continued during the past year with gratifying success. These consist in what may be termed "common-sense" engineering, the practice being to plan the work in advance, wherever this is possible, and to provide for its accomplishment the proper labor and tool equipment. In addition, a man has been assigned to the sole duty of studying shop conditions and methods with a view to making changes in any direction which would promote efficiency. Piece work has been introduced in the armature room, the foundry and the paint shop, while in the machine shop a part of the work is paid for on the same basis. When repairs are planned, an endeavor is made to bring into the shop all trucks and car bodies of any one type during one continuous period,



Cleaning Cars with Motor-Driven Brush, Hudson & Manhattan Railroad

and thus specialization in the work is permitted. To the same end, pieces which require a special setting for the machine tools are always put through in large lots, and the supplies are kept well ahead of the normal requirements to eliminate costly rush jobs.




Views Showing Flush Transfer Table Used at New Detroit Shops

Such methods are, of course, greatly different from the efficiency engineering which insists upon the use of stop-watch investigations for the establishment of an exact "standard time" for performing every operation in the shop, the payment of large bonuses for work done in less than standard time, the allowances for unavoidable delays, and the creation of elaborate planning departments, speed bosses, tool bosses and dispatch boards for routing material and scheduling operations. Yet it undoubtedly is along lines of such simple and flexible methods as those used in Boston that the most effective improvements in electric railway repair shop practice have been and will be made. Indeed, more than one shop designer has appreciated the fact that there are many methods for increasing productive efficiency. One of the most obvious of these is to place the workman in favorable surroundings and to provide him with proper tools. This, it may be said, is a prominent feature in the design and equipment of the new Montreal shops, where it appears in such ways as the ample natural lighting, the perfect drainage, the adequate ventilation and heating, the mastic asphalt floor which makes walking easy, and finally the abundance of transporting machinery and air-operated hand tools which eliminate heavy physical labor entirely.

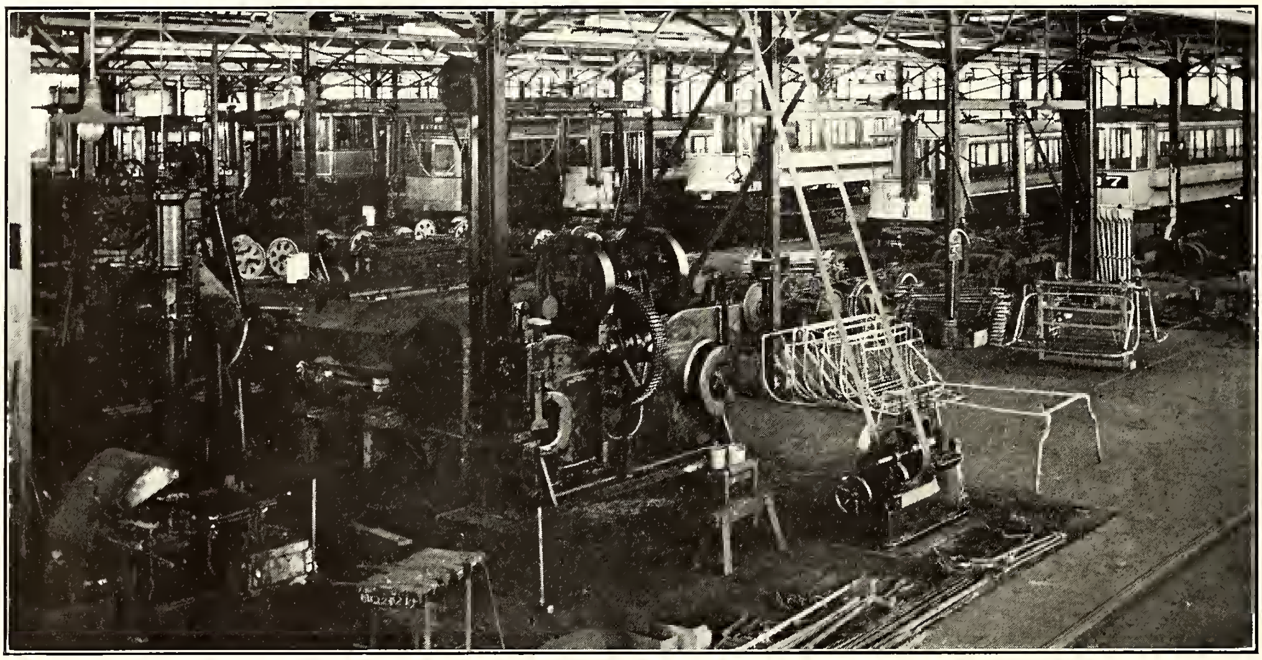
Sash Room at End of Paint Shop, Montreal Tramways

PREMIUM PLANS FOR WAGE PAYMENTS

As before mentioned, the problems of true scientific management, which should include every link in the chain of production from the design and equipment of the shop buildings to the handling of the finished product, have to a great extent become obscured by the importance which has been popularly assigned to special forms of payment for the workmen. A really vast amount of attention has been devoted to the introduction of piece work, and, indeed, it is obvious that in certain departments of the repair shop such a system of payment may be introduced to good advantage.

On a number of roads wheel turning has been placed upon a straight piece-work basis, and in other cases this class of machine work is being paid on a bonus system which assures the workman's day rate in any event but provides a premium or "bonus" in case more than a certain amount of work is completed. On the Hudson & Manhattan Railroad an ingenious premium plan for turning steel wheels has been in use for several years with thoroughly satisfactory results. This provides a bonus for keeping down the weight of metal removed, the system of payment having been described in the ELECTRIC RAILWAY JOURNAL for June 24, 1911.

In the paint shop also the work is not only definite in character, but with comparative ease it can be planned in advance to follow an exact schedule. The variable factors of unknown value are negligible, and payments which are based upon the finished job may be made in every case with justice to employer and employee. The same condition exists in the armature room. Here the work involved in stripping an armature will remain practically at a constant average for any given type of motor, and all subsequent operations, such as laying in and connecting coils, banding and the slotting of commutators, involve new work which is invariable in amount and may be paid for by the piece without penalizing the workman through his ill luck in getting an unusually difficult job. In many of the other departments, however, equivalent conditions do not hold, and here the inability of knowing in advance the exact extent of any piece of work places difficulties, which, however, may not necessarily be insurmountable, in the way of premium plans for payment of employees. To be reasonably successful, these plans must be always just, and in addition must be stable, so that the establishment of a satisfactory premium system is no easy matter even under the most favorable circumstances. Indeed, it is obvious that all operations should be made as efficient as possible under an existing system of payment before the adoption of a new system becomes in any way a logical step. Efficiency of operation and the elimination of lost motion alone are matters which may, in fact, be studied to excellent advantage in any shop even if there is to be no change in the wage system.



Electrical Shop Section of Main Repair Shop, Montreal Tramways

IMPROVING OPERATING EFFICIENCY

Such a course has been followed by a company whose management has been characterized to a remarkable degree by an untiring search for improvement in every department, and an efficiency campaign was inaugurated in its mechanical department several years ago.

The first step in this work was to segregate the shops into various divisions, with the lines drawn very sharply. That is to say, in the general shops, certain parts of the machinery in each department were set aside for the hit-and-miss operations, the rest being turned into practically a manufacturing organization. The operating or depot crews were thereby entirely divorced from connection with the shop repair division and manufacturing division.

From data gathered it was found possible to set aside also certain pieces of machinery in the shops for distinct classes of work, and these certain machines were equipped with the most improved devices for securing a high degree of production. All repairs of whatever nature to the various parts of the car equipment were taken out of the hands of the operating or depot crews, and sufficient stock of the various classes was furnished in a complete condition, so that the only duties which had to be performed by the operating or depot crews were those of inspection and the oiling and renewal of parts. The inspection was carried out largely by the use of limit gages, and if the parts were found in such condition as to require replacement, the carhouse employees merely made the renewal and returned the worn part to the storeroom.

To illustrate, an 18-in. engine lathe in one of the shops was fitted up with special tools, jigs and gages and placed in the hands of an experienced operator on turning and chasing. This particular machine now makes all armature shafts and similar shafting for the complete system. Another machine furnishes all of the armature and axle bearings for the complete system. Where formerly trolley wheel, harp and pole repairs were made at the various carhouses or operating depots, under the plan adopted by the efficiency committee a drill press and various other pieces of machinery for handling trolley wheels, cotters, trolley spindles, trolley poles, etc., were set aside in one of the shops, and the operator was trained in quick methods for repairing and assembling these parts. This one man now does all of this work, and when a trolley inspector finds that a trolley bushing or trolley pole is worn out all that he has to do is to remove the complete harp and wheel and replace it, returning the worn-out one to the storeroom on the supply car.

The manufacturing division furnishes practically no material directly to the operating division of the mechanical department. All supplies are furnished from the storerooms under the supervision of the general storekeeper. When equipment parts are returned from the operating depots they are returned to the storeroom. The storeroom places an order on the manufacturing division of the shops either for the new parts or for the repair of old parts furnished by the storeroom. The manufacturing division then completes the order and furnishes the material to the storeroom, and the maintenance accounts are credited accordingly. The maintenance accounts are charged at the same price when the material is delivered to repair or to operating divisions.

One of the latest additions to the efficiency scheme on this same road is the purchase of a special machine for high-speed, heavy-duty drilling, used for truck parts particularly. This machine is so constructed that it will drive a 1¾-in. drill through crucible cast steel at the rate of ½ in. per second, and it is being equipped with jigs fitted to every type and class of casting which will be handled upon it. It is expected that this one machine with one operator will machine all the truck castings used on the system, replacing three machines and three operators, yet it will be busy for only part of the time. To illustrate the advantage gained by this scheme, it should be noted that a brake hanger bracket used on a certain type of truck was drilled under the old method at the rate of one every fifteen minutes. Under the new arrangement, these will be completed at the rate of thirty per hour.

IMPROVED METHODS IN THE ARMATURE ROOM

Several years ago this railway had three winding rooms. To improve the operating efficiency an extension to one of the winding rooms was made, and all armature winding was brought to this one place. When the position of the machinery, the workbenches and other apparatus in the building was re-arranged, special care was taken that the part to be repaired should never make a backward move. The course of an armature through this room is now as follows: It arrives in the supply car and is placed on an inspection platform, at which point the inspector determines what repairs shall be made. All armature winders are specialized on certain types of motors and certain classes of repairs, and if a particular armature is to be rewound and receive a new commutator, it goes to a stripper whose duty it is to remove the coils and the commutator and straighten the core and its laminations. It is then picked up by crane and placed on a machinist's bench, where the commutator, end bells, etc., are applied. It is then moved to an insulator's bench by the same crane, and he applies all slot and core insulation. From that bench it goes to a winder, who applies the coils and connects the leads to the commutator only; then it passes to the solderer's bench, where the armature coil leads are soldered to the commutator; then to the banding machine, where the armature is banded, and then to the turning lathe, where the commutator is trued. From the turning lathe it goes successively to the grooving machine, to a testing bench and to a machinist's bench again, where the bearings and pinion are applied, and finally it arrives in the storage rack at the other end of the shop, next to the supply car track, ready for shipment. The men have become specialists and have reduced the time required for winding a 60-hp armature from eighteen hours to eight hours, in addition to applying the bearings and pinion, which had not been done before this new scheme was put in effect. Half of the extension originally made to the building is now being used by another department.

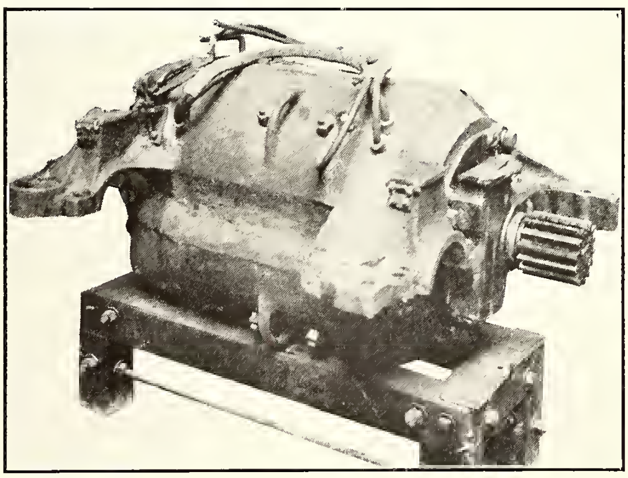
Wood Mill in New Shops of Montreal Tramways, with Concealed Shavings-Exhaust Pipes

TENDENCIES AND RECENT DEVELOPMENTS IN SHOP PRACTICE

In addition to the improved methods which have been developed in repair shop operation, the past year has seen the crystallization into thoroughly approved practice of several comparatively recent innovations in methods of doing work. Among these are a number quite revolutionary in character but which give evidence nevertheless of an ability to effect considerable savings in maintenance costs, such, for instance, as the substitution of baking enamel in place of air-drying paint and the use of welding

Electric Heaters Hung in Car for Baked Enamel Painting, Hudson & Manhattan Railroad

by means of the electric arc or other special methods which eliminate the forge and permit the building up of metal as well as the joining of two broken parts through the application of intense local heat. At the same time, the tendencies displayed by electric railways toward greater conservatism in home manufacture, as well as a greater amount of system in handling manufactured articles, and also toward the universal establishment of the mileage basis for making inspections and repairs, will



Solid Frame Motor Made from Old Split Frame by Electric Arc Welding

undoubtedly play an important, although less spectacular, part in the reduction of maintenance expense.

BAKED ENAMEL PAINTING

Baked enamel as a substitute for air-drying paints and varnishes has been in use for a long period in the automobile industry, but it is only within the past year that it has been applied to railway cars. With air-drying paints the most elaborate methods of application have become customary, and in consequence the adoption of this new and simple process constitutes one of the most radical innovations in the history of shop practice. On the Hudson & Manhattan Railroad, where it was introduced last winter, it has been adopted as standard, and since then it has been taken up by the Pennsylvania Railroad for its steel passenger coaches. Details of operation on both railroads were given in the ELECTRIC RAILWAY JOURNAL for Jan. 25, 1913, and April 12, 1913.

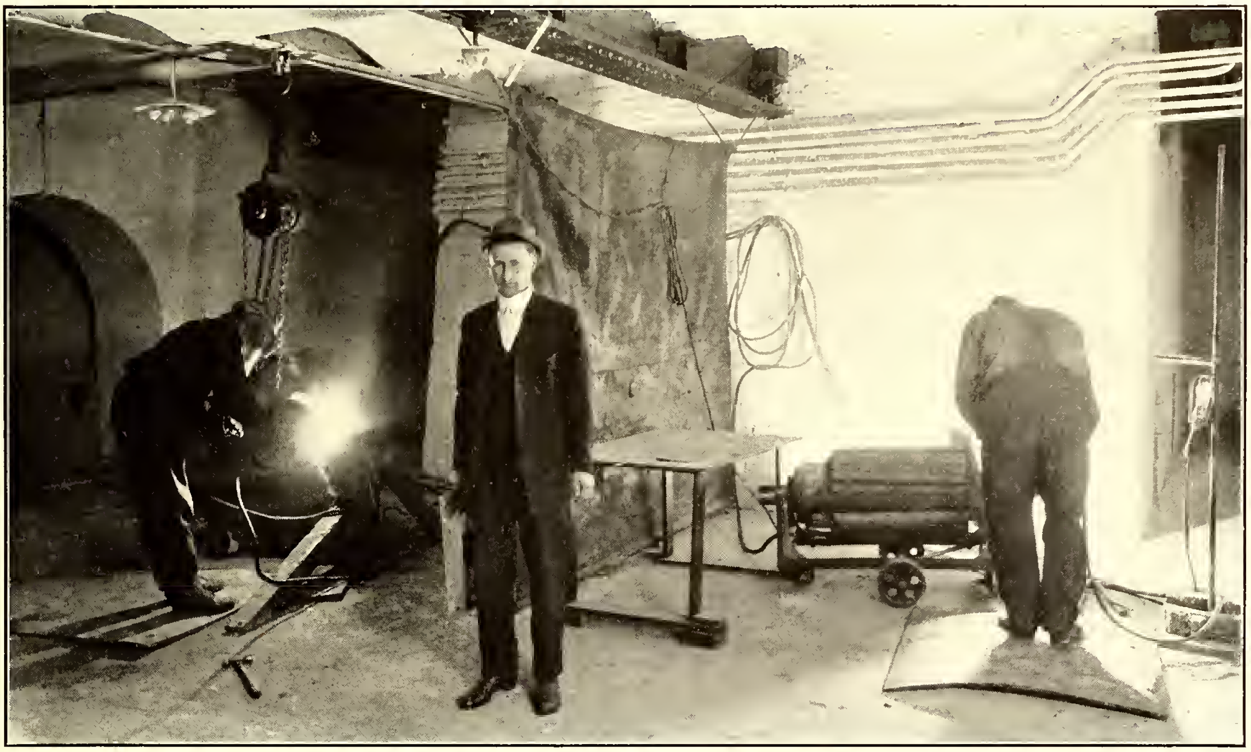
Briefly the process consists in the substitution, for the customary paint made up of pigment ground in linseed oil,

Old Grid Resistance for Reducing Line Voltage for Electric Arc Welding, Third Avenue Railway, New York

of baking enamel composed of pigment ground in varnish and prepared with special reference to rapid drying under artificial heat. The most important feature of the process is the extraordinary rapidity of the work, for the baking of a single coat requires but about three hours, and four coats can be put on with a reasonable allowance of time for application in about two days. This naturally effects an enormous saving in time and shop space and, unless a "flat finish" is desired, in labor as well.

On the Hudson & Manhattan Railroad only the interiors of the cars are thus treated, the exteriors on account of the tunnel service receiving only enough attention to keep them from rusting. The high temperatures required, ranging from 130 deg. to 200 deg. Fahr., are obtained through the novel expedient of hanging three extra equipments of electric heaters from the hand rods in the car, and the desired temperature is maintained by turning on and cutting off current from them in accordance with the requirements as indicated by a thermometer inside of the car.

On the Pennsylvania Railroad a kiln has been constructed of a size sufficient to contain a standard steel coach. It is heated by live steam at approximately 100 lb. pressure, supplied to pipes hung on the walls. This gave a direct radiating surface of about 2000 sq. ft. Four 8-in. Globe ventilators in the roof provide a mild circulation of the air in the kiln. Cars are run into the kiln with doors and windows removed after having received a coat of enamel both inside and out, and they are baked at temperatures ranging from 120 deg. to 250 deg. Fahr. The results both for exteriors and interiors are reported to be most satisfactory, not only through the quickness with which the work can be done but also in the improved appearance of the cars both inside and out and in the superior hardness and ability to resist the abrasive action of dust possessed by the enamel.



Welding with Electric Arc, Third Avenue Railway, New York

The cost of the process, including the expense incidental to the heating of the kiln or car interior, is about equal to that of high-grade painting as ordinarily carried out, so that on account of the greater durability of the covering the baked enamel process effects a net saving over the common method exclusive of the benefit obtained through the 75 per cent reduction in the time spent by the car in the paint shop.

SPECIAL WELDING PROCESSES

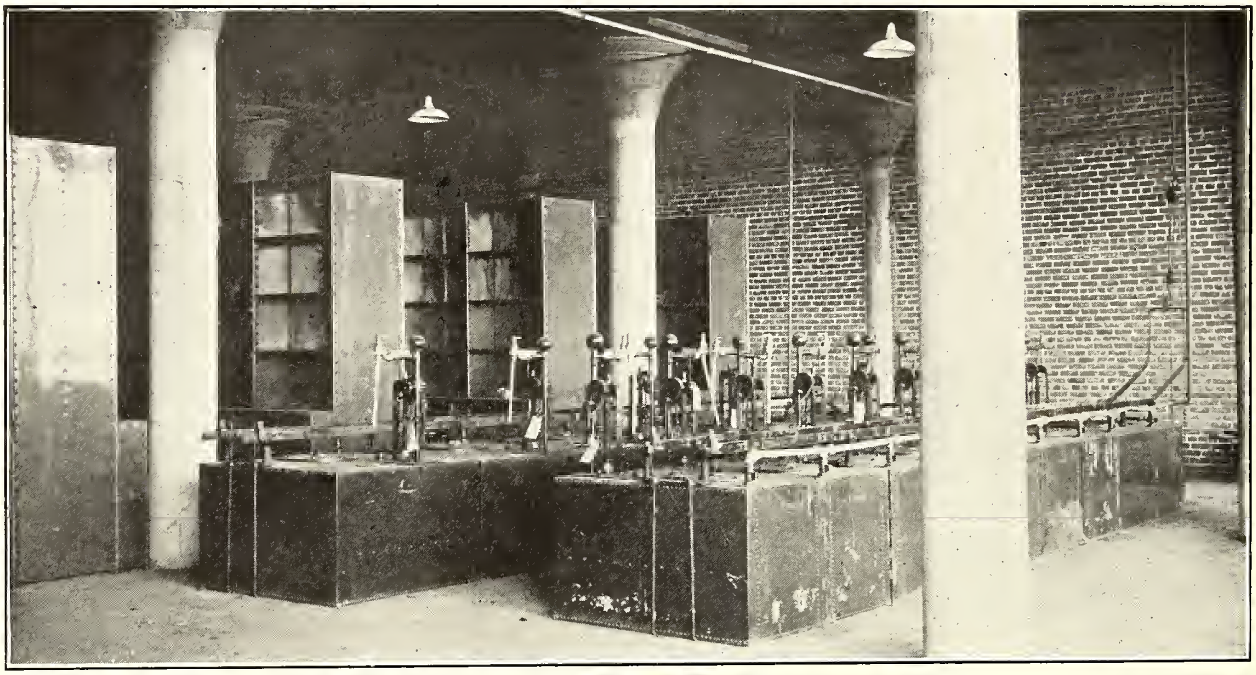
The practice of prolonging the life of worn or damaged equipment by welding promises to become widespread now that the causes for initial failures have been learned and corrected. The process came into practical use only about 1910, and among the early companies to adopt the system of arc welding for this purpose were the Philadelphia Rapid Transit, the Pittsburgh Railways, the United Railroads of San Francisco, the Third Avenue Railway of New York and the Montreal Tramways. The earlier welding was limited to armature shafts and other small work, but the descriptions of the San Francisco and Third Avenue installations, as published in the ELECTRIC RAILWAY JOURNAL of May 17 and June 21, 1913, respectively, show the amazing versatility of electric welding, not only on truck frames, axles and shafts, but for the complete reconstruction of motors for oil instead of grease lubrication, for filling dowel-pin holes, patching gear cases and similar building-up operations.

It is customary to step down the line voltage to from 50 volts to 80 volts through grid or water-barrel resistances, as all railway companies do not seem to think that motor-generator sets would save enough to warrant their purchase. Oxy-acetylene welding is used to a limited extent for small work, and particularly where cutting is desired, but it does not equal electric arc welding for heavy work.

The principal expense involved in electric welding is for current, which is usually taken between the rush hours and charged against the welding jobs at 3/4 cent to 1 cent per kw-hr. Flux powder is very cheap, the Third Avenue Railway paying only 8 cents per pound for it, while the Montreal company makes its own compound of 28 per cent sodium carbonate, 70 per cent crystalline borax and 2 per cent red ocher. Alumino-oxide welding has also been used successfully for a wide variety of conditions, the principal objection to it being the cost of the reaction powder.

HOME MANUFACTURE

Home manufacture varies considerably in extent, depending upon the size of the property and its nearness to the supply market. In some cases, like that of the Public Service Railway of New Jersey, part of the rolling stock is built at the shops complete, not to save money on individual cars, but to maintain a high-grade shop force by minimizing the fluctuations which are common to straight maintenance work. The Brooklyn Rapid Transit Company was the first company to do similar work with steel cars, for all of its new center-entrance cars were completely equipped from the skeleton up at its own shops. In this instance the company felt that the novelty of the design and the large number of cars made it advisable as well as profitable to assemble the equipment at the home shops.



Bins and Pumps in Paint Stock Room, Portland Shops

So far as the home manufacture of small parts is concerned, a decided tendency toward more businesslike methods is apparent. In former years such work was done in an inefficient, hand-to-mouth way, but now it is more customary to keep some stock on hand and refuse to undertake the manufacture of less than a specified minimum. On some systems the purchasing agent calls for competitive outside bids, and the shops do not get the work if their prices are higher after, say, 15 per cent has been added for overhead charges. Recourse to such bidding has been found very useful in discovering weak spots in manufacturing methods, and it has shown especially that work for other departments should be considered with caution when the parts wanted call for unusual skill in manufacture.

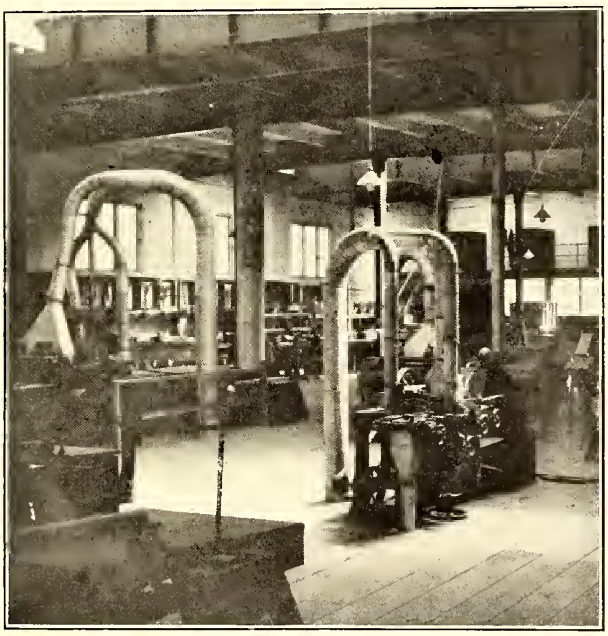
The methods of distribution of manufactured or new parts have of late displayed a distinct tendency toward standardization. On the Montreal Tramways the car maintenance department is responsible for all supplies which are capable of re-use from the time they leave the stores department new until they can no longer be economically repaired. For guidance, every carhouse is supplied with a list of renewable parts. The supply car of the stores department is employed for collecting and distributing such materials, but their actual stocking, repair and circulation is a purely internal affair of the car maintenance department. All other supplies, however, are ordered from the stores department direct. The most advantageous feature of this system is that the head of the car maintenance department has much closer super-

Jib Cranes and Hoists for Handling Wheels to and from Wheel Lathes, Brooklyn Rapid Transit System

vision over the use and return of materials than if the goods were handled through the general stores. The carhouse foremen have no voice in deciding what shall or shall not be scrapped. They must send their discarded material to the main shops, where two men distribute it into piles of renewable, doubtful and scrap material. In addition, before final disposition is made, the general foreman examines the doubtful collection himself. The parts are then sent to the shop for renewal and upon repair are turned into the stores of the car maintenance department. There they are subject to requisition from the carhouse foremen, who in general must return a worn part whenever they apply for a replacement.

The usual sub-stores are, of course, provided at all car stations, and their operations are checked monthly to make adjustments for lost articles, etc. Sub-stockrooms are also installed at the main shops under care of the respective sub-foremen. About 90 per cent of the material used by the men is brought to them by boys.

Department for Curtains and Hand Straps, Brooklyn Rapid Transit System



Wood Mill, Portland Shops

MILEAGE MAINTENANCE

Very few objections are heard nowadays against the maintenance of car equipment on a mileage basis. The companies which still stick to definite time intervals for doing this work do not generally deny the superiority of the former, but they appear to be afraid of the cost of record keeping. It has been abundantly shown, however, that except on the smallest railways the wage of a mileage clerk is a negligible amount compared with the advantages of a more exact knowledge of what each class of equipment can do.

On one system which is operating without mileage records, for example, the manager proudly asserted that his oldest motors were seen on the defect sheet no oftener than his modern equipments, but a question put to the master mechanic brought out the fact that the ancient equipments were not in service for more than an hour or two morning and evening. Even a straight mileage system is not a fair criterion of the comparative merits of the equipment unless the character of service is substantially the same in all cases, and in consequence companies which operate a variety of equipment are no longer fixing the same inspection and overhaul mileage periods for all classes indiscriminately but are instead determining by experiment the critical figures for each type of motor and controller.

FARE ACCOUNTING

THE collection of the fares of an electric railway company and the establishment of proper and complete protective measures to safeguard the revenue constitute one of the most serious problems that confront the companies.

When the operation of street railways began the methods adopted for the collection of fares were crude and simple and they involved few, if any, of the safeguards that have been introduced in later years. The operator of the car or the conductor was responsible for the collection of the fares, but few steps were taken to make it certain that all the fares were collected and that they all reached the coffers of the company.

As the companies have progressed in the adoption of new standards and practices in other departments, the subject of the collection of fares and the accounting therefor has aroused increased interest. Less progress, however, has resulted from the attention given to this subject than from the efforts made in the departments that have to do with the physical railway operating property. The reason why a complete, satisfactory system has not been adopted universally lies in the complexity of the problem and in the fact that it involves questions partly or wholly out of the control of the management, such as the honesty of the traveling public and of the conductors.

The collection of revenue of a street railway company operating in a city involves a problem that is different from that concerned in any other form of business having as large earnings or capital investment. Of course, the railway has an advantage in the fact that every transaction between the company and a customer is a cash one and that substantially no credit need be extended. This very advantage, however, opens the way to risks against which the company must protect itself, because it means that money or its substantial equivalent in tickets must be handled in every transaction. The amount of each fare unit is small in the case of a city company, and it is not large even with the interurban companies. The small size of the fare unit is a disadvantage because it reduces the amount of the expense for protective measures which the company can afford to pay. If, for instance, a company receives a fare of 5 cents from each passenger, it cannot afford to pay out a large part of the fare in order to make sure that it receives the balance. On the other hand, it must take some protective measures. If, however, it has to pay too much for protective measures, its cost of operation is too large.

A trunk-line steam railroad requires every passenger to buy a ticket before he boards the train. A long-distance passenger will spend so many dollars for transportation, berths, etc., that a company can afford to have an elaborate scheme of numbered tickets, together with reports, making a complete protective system. The same plan is carried out ordinarily on the passenger trains which are operated for short distances and on railroad lines of medium-size mileage. Even in cases where passengers board steam railroad trains without having purchased tickets in advance, the number of such passengers is small in comparison with the total number on the train. The amount of possible loss, therefore, is light in comparison with the amount of revenue which the company is certain to secure from passengers who comply with the rules by buying their tickets in advance. The collection of fares on long-distance steam railroad trains has been developed to such a point that, between the Pullman conductor and the conductors of the railroad company who are responsible for the operation of the train in the various divisions, no chance is left open to the dishonest passenger, while the number of persons that would have to be involved if the employees should try to withhold revenue is so large that the company is reasonably certain to obtain the rightful fares.

This condition, of course, does not apply to the denser commuter traffic of the steam railroad companies. In some cities companies have had to take vigorous steps to guard themselves against the practices of both dishonest passengers and dishonest trainmen.

In all forms of business which involve public dealings the companies concerned introduce carefully devised systems for the extension of credit and for the protection of their revenue and interests against possible dishonesty, and in so doing they do not experience the same kind of difficulty which is usually met by the street railway company. Many of these forms of protection are based on some sort of a prepayment scheme or advance which is in the nature of a trust. A depositor in a bank, for instance, surrenders his funds to the entire control of the bank save for an entry in a book or a certificate, and he receives the benefits of the accrual of interest thereon when it is credited at the end of the period stipulated. A patron of a penny-in-the-slot machine surrenders his coin before he gets what he wants. The user of a telephone who wants an instrument placed in his home or office has to contract for it for a fixed period and ordinarily pays a rental in advance. One steam railroad company which has a large suburban business found that it was being defrauded of part of its revenue and introduced an elaborate scheme providing for the surrender of the tickets of all pasengers within an inner zone on the traffic movement outward from the central terminal. This scheme provides also for the partial cancellation of tickets at the terminal before passengers on all movements to an outlying zone board the train.

Some of the various protective methods that have been introduced in other forms of business involve much more inconvenience to the public concerned than any of the steps for safeguarding the revenues that have been established by street railway companies. So far as the passenger is concerned, all that the advanced method of city railway operation asks is that the fare shall be paid at the time of entrance to the car. This is asked by the companies in pursuance of a principle that has received wide acceptance in the industry. This principle meant reform in two directions. It meant that the passenger would have no means of evading the payment of his fare unless he did so through collusion with the conductor, and it meant that the conductor would have more of his time free for watching the passengers board and alight from the car and could therefore have a great influence in the prevention of accidents. It made collusion between the passenger and the conductor who wanted to defraud the company of a fare much more difficult because it made the collection of the fare or the failure to collect the fare a conspicuous act. It deprived the passenger who was willing to be dishonest of the opportunity which he used to have of burying his nose in the daily newspaper when the conductor was trying to collect fares. It deprived the dishonest passenger of another and more brazen type of the opportunity which he used to have of trying to browbeat the conductor into the belief or the fear that he had paid his fare previously. Therefore, where the prepayment system of fare collection has been adopted, it may be said to have disposed almost entirely of the problem of fare collection so far as it relates to the willingness of passengers to avoid the payment of fare if possible.

No solution has entirely answered all questions concerning the attitude of conductors on this important point. Some employees object to any protective measures that the company takes. They regard such measures as a reflection on their honesty and good intent. When they do so, however, it is doubtful if they stop to consider the rigorous degree of the measures adopted in other forms of business where money matters are concerned.

It is in banks that ordinarily the most stringent provisions against possible dishonesty are adopted. There, of course, the money is the commodity on which all the transactions of the institution are based. The amount of actual revenue derived from the loans, dealings in securities, etc., is very small as compared with the actual volume of transactions, and, furthermore, it is represented generally by bookkeeping transactions on paper rather than by actual cash. The bank usually bonds its employees. It has systems of checking and re-checking both cash and securities, and while defalcations occur on the part of both minor employees and leading officials, they occur in spite of the safeguards introduced and not because no safeguards have been established. By most bank employees the protective measures are regarded as safeguards for themselves as much as for the bank.

The street railway company which has not adopted improvements over the primitive system of fare collection still has before it opportunities of bettering its position in regard to income. Many accountants are considering the problem which this matter involves; they are handicapped in their efforts by the fact that they have practically no recognized control over the men on whom the company is forced to depend. These men are in the transportation department and are therefore responsible to another official. However, the extension of the prepayment principle has led to the development of other safeguards in the form of fare boxes, as well as to more careful supervision and training of trainmen, with the result that the companies generally are obtaining a larger proportion of the revenue due them than ever before.

That there is room for further study and improvement is realized by accountants generally. Some of the accounting officials of city and interurban lines have discussed present practices and advanced ideas for further improvement in letters written to the ELECTRIC RAILWAY JOURNAL. These are published below.

CHICAGO

F. E. Smith, comptroller Chicago Railways Company, expressed the following opinion:

"It seems to me that so far as the accounting for cash fares is concerned there is little room for improvement, but that the ideal method of collecting all fares is the serious problem with which we have to deal. As our method of accounting may vary somewhat from that in general use, I will explain it briefly.

"Each night, after all cars are housed, a night clerk, with a list in numerical order of all the registers kept at that station, makes the rounds and examines each one and notes on his slip the closing number. A copy of this is sent direct to the accounting department. These closing numbers are listed on adding machines, and from the total is subtracted the total taken from the list of the previous day. Reports are sent in, showing the number of fares rung up for testing or other purposes, and the total of these is deducted from the day's total as shown by the subtraction of the closing numbers for the two days. The balance is what we expect the station receiver to account for so far as 5-cent fares and tickets are concerned. If the receiver's report agrees, we consider the station is checked; if there is a discrepancy, a check of the several routes is made and the discrepancy located by routes. Then the registers used on those routes are checked to locate the conductors at fault.

"A daily station register report is made and sent direct to the accounting office. This is kept by routes; it shows the 'register number,' 'run number,'' 'line,' 'out,' 'in' and 'difference.' This repeats five times across the sheet, and then are shown the 'total' and 'remarks.' So far as is possible an effort is made to keep a register on the same line throughout the day, and to have them go out in numerical order. This facilitates checking, as we can take them in blocks. As each line on the form permits of the use of a register five times, it is very seldom another line has to be used to get the total for the day.

"Each time a car is pulled into the station a record is made on this sheet of the register reading, and the clerks see that the next conductor takes it out with the same reading. When conductors are relieved on the street our rules require the one leaving the car to see that the one that takes it shall enter upon his trip sheet the same number as 'opening number' that he has used as 'closing number.' For these runs the station clerk copies these opening and closing numbers on his sheet from the trip sheets. The night clerks make the subtractions and the totals for the day. These sheets are then turned over to the receivers to compare with their totals, and many errors are discovered by them and shortages made good out of their 'bank.' This materially reduces the number of 'over or short' reports to be made in the accounting department, but enough errors are detected and collected by the accounting department to more than pay the salaries of the clerks engaged in the work.

"The 3-cent or half fares are checked as follows: Each trip sheet has a slip that is detached by the receiver when a settlement is made at the close of the day's work, on which the conductor is required to punch the number of such fares collected. These punch marks are counted both by the receivers and the accounting department. This company does not register transfers.

"In my opinion the ideal device for the collection and registration of fares has yet to be invented. This company has had on trial several devices, and none of them has given the satisfaction that had been anticipated. Why cannot some inventor devise a machine along the following lines:

"Have plates with depressions in them in which the various denominations of coins may be placed so that the coins may be inspected by the conductor before he trips the plate; make the tripping device do the registering after the manner of the comptometer, i. e., in order to trip a quarter the pressure of the key would register five fares, to trip a dime would register two fares, etc. It seems to me that slots could be devised that would grip a ticket or transfer, and the operation of the device would draw it into a receptacle and register them one at a time. It would seem as though the transfers could be carried to a box where they would remain in the order in which they were collected. It all sounds so easy that I warn inventors that if they don't hurry and bring out such a machine, I am likely to devote an evening to doing it myself."

MEMPHIS

W. H. Burroughs, secretary and treasurer Memphis Street Railway, writes as follows:

"The methods of the different street railway companies in accounting for fares, from the time they are collected by the conductor until they are deposited in the bank by the treasurer, are so varied that a suggestion that will apply to all is somewhat difficult.

"The adoption of the prepayment plan in the collection of fares by conductors by many, if not most, of the companies has eliminated to a large extent the necessity of educating the public in the matter of fare collection, except to have the exact fare ready when boarding the car. The great problem, as we see it, is to be assured the fare will reach the hands of the treasurer and ultimately the coffers of the company. We believe the fare box, when perfected, will be a great factor in securing to the company a correct accounting for its revenues.

"The fare box will not, however, eliminate the human factor. We find it necessary to check our conductors frequently to see that all fares collected are properly registered. For this reason we would not consider the abandonment of the use of fare registers even though we should adopt the fare box, for any system in which the use of the fare register is abandoned and in which the company has no means of checking its conductors thoroughly we consider necessarily bad. The combination of a good type of fare box with a first-class fare register, followed up by a thorough system of inspection, should produce good results. We use both open and secret inspection and have secured good results.

"The accounting for fares, after collection and registration by the conductor, should not be a difficult matter. The reading of the registers and the receiving of money from the conductor in the settlement for the day should be done by different men, the register reader reporting to the auditor of the company and the receiver to the treasurer. The auditor, after balancing the trip sheets of the conductors with the register readings taken from the cars, should give the treasurer a statement showing the total amount of money due the company. This will enable the treasurer to check the money turned in by the receiver. Everything should be made to balance with the readings of the registers.

"In conclusion, we might add that we think the loyalty of its employees has much to do with the company receiving a just accounting of its revenues. The adoption of the latest and best improved mechanical devices, unless operated by satisfied, loyal employees, will in no wise achieve the desired result."

SPOKANE, WASH.

George B. Colpas, auditor Washington Water Power Company, Spokane, Wash., said:

"We use the International register and pay-as-you-enter cars. Conductors ring up on the cash side of the register cash fares and pay tickets; on the transfer side conductors ring up transfers and passes. We charge 5 cents each for cash fares and sell twenty-two tickets for $1, also sell tickets to school children of proper age at 2½ cents each. Carhouse employees take the register reading of every car in the morning and again at night when the cars are returned to the barn. These readings are checked against the conductors' trip sheets. Transfers and passes taken up are placed in an envelope, and at the end of each trip this envelope is deposited in a glass box in the car. When the car is returned to the carhouse at night, the carhouse employees take the envelopes out and forward them to the audit office for checking.

"On the face of the envelope is printed a blank report which the conductor fills out before depositing it in the box. The report gives the following information: Date, line, car number and time, also the numbers of transfers issued and the number of fares collected. In the audit office transfers are counted and the time punched is compared with the running time, and conductors are advised of irregularities.

"A comparison of the present earnings per passenger (which includes all pay passengers and transfers) with the earnings per passenger before we commenced checking the time on transfers shows that our earnings per passenger have increased about seven-tenths of 1 mill. If it is the check we have placed in effect on transfers which makes this increase, the small additional amount expended in clerical help is well repaid."

INDIANAPOLIS, TERRE HAUTE & EASTERN TRACTION COMPANY

L. T. Hixson, auditor Terre Haute, Indianapolis & Eastern Traction Company, said:

"There has probably been less progress in the matter of accounting for fares than in any other branch of the railway business. When tickets as well as cash fares are accounted for by conductors a register of some kind is generally used. In case the conductor is required to account only for cash fares, when such fares are collected, the usual practice is to use either a register or cash fare receipts of some kind. None of the systems appears to be entirely satisfactory. If the proper amount of statistical information is shown, the conductor is overburdened.

"The item of first importance is the collection of all fares and the proper accounting for such fares to the company as to value. Statistical information is of secondary importance, although it is quite necessary to a certain extent. Therefore, in order to get the best results, the first step is to make the collection of fares as easy as possible and require the conductor to make only such records as it is impossible to get from some other source.

"There is no argument as to tickets being more easily collected than cash fares. Such being the case, it should be the first duty of the company officials to induce passengers to purchase tickets. A passenger would naturally prefer to pay a cash fare on the car, unless he has some inducement for purchasing a ticket. If he has baggage to check at an agency point, it will be necessary for him to get a ticket, or, if the rules of the company require a passenger to show a ticket before boarding the car, the passenger would purchase a ticket. But in a great majority of cases he has no baggage to check, and the rules of the company do not require a ticket to be presented before he boards the car. In fact, the latter rule could be enforced only at a few large stations, and even in such cases city ordinances usually require cars to stop at street crossings to take on and let off passengers. Therefore the only practical solution would be to make the ticket rate slightly lower than the cash fare, as the greatest inducement to the public is a matter of dollars and cents. This reduction in rate could be very slight and still have the desired effect, although it would be necessary to have a cash fare which would allow of this reduction and still give the company a fair return.

"In order to avoid the point of discrimination which might be brought up by some patron who lives near a fare point at which no agency is maintained, such tickets might be in the form of single tickets good between certain stations and also good for a year from the date of purchase, and in that way they could be purchased in considerable quantities at an agency point. There would be no difference, so far as discrimination is concerned, between these tickets and the ordinary interchangeable mileage book.

"Assuming that a company has followed the plan above suggested, there will always be a few cash fares, principally 5-cent fares, on which there would be no reduction in the ticket rate and fares paid by strangers. It is generally conceded that a conductor can collect cash fares more rapidly by the use of a register which shows only the amount of the fare and does not show the boarding and destination stations. A register of this nature will not give statistical information of any value. There have been some experimental registers designed to show all classes of statistical information covering both tickets and cash fares, but these registers, with the possible exception of one, have not proved to be a success. So far as statistical information covering cash fares collected is concerned, the cash fare receipt in one of the forms now in use is probably the most satisfactory.

"The principal objection to this cash fare receipt is that the work of the conductor is increased, and that the interests of the company are not sufficiently safeguarded. However, there has recently been put on the market a receipt consisting of auditor's stubs in duplicate and a passenger's receipt. When the cash fare has been punched, the passenger's receipt is detached and given to the passenger, and the auditor's stubs are sent in to the auditor without being torn at the side perforation. It is impossible to split this cash fare receipt without detection, and the passenger's portion is in such form that it is very difficult to manipulate.

"The objection usually made to allowing conductors to turn in tickets without showing value or stations from and to is that a conductor might very easily substitute tickets of smaller value for those of greater value. While this is true, the same thing could be done if he were required to make a record on a register, although in the latter case the passenger would have some check (if he desired to take the trouble to make this check). The surest way, however, is to have secret service men make the on and off check on various runs at different times.

"Summing up the matter, I am in favor of the following:

"First—Give the passenger some inducement to purchase a ticket.

"Second—Until such time as a register is produced that will give the necessary statistical information, a receipt should be given for cash fares collected, such receipt to be of the three-part type mentioned above.

"Third—Cash fare receipts should be used for cash fares only, and not for destination checks.

"Fourth—Printed hat checks showing station names and bearing consecutive numbers should be used, such hat checks also to be used for destination checks, in case of swing runs, etc.

"Fifth—Tickets should be reported by the conductor in total without classifying.

"Sixth—As a general proposition, a conductor should be required to make only such records as are absolutely necessary and which cannot be obtained from any other source."

UNION TRACTION COMPANY OF INDIANA

Walter Shroyer, auditor Union Traction Company of Indiana, has written the following:

"Accounting for fare collections on interurban railways offers many problems which have never been satisfactorily solved. All of the various methods now in vogue undoubtedly have some merit serving to attain the desired results, but none seems to be perfect.

"One of the interurban lines operated by this company was among the first, if not the first, operated in Indiana, and it may be of interest to outline the methods of fare collections employed from time to time. The first plan in vogue was to collect by zones, requiring each passenger to pay a 5-cent fare for each zone traveled over, each fare being rung up separately on a small portable register. A through passenger traveling between terminals, a distance of 34 miles, was required to pay his fare seven times, the fare at that time being 35 cents. If this system was still in effect, a passenger traveling on one of our through limited trains between Indianapolis and Fort Wayne would be required to pay his fare forty-five times. This system proved impracticable and was soon discarded.

"The next system put into practice was the torn ticket. This ticket had all stations printed across the top, also down the left-hand margin, the tearing being regulated by a metal square, which would leave the amount paid by the passenger upon each portion of the ticket in the angle of the square. One portion of the ticket was handed to the passenger and the other was sent to the auditor. Tickets were consecutively numbered and conductors were required to account for all that were issued to them. The principal difficulty with this system was the inaccuracy of the conductors in tearing the tickets, and in a great many cases it was impossible to determine the correct amount of the collection made. This system was operated without registration. The tickets were very slow of audit and this system was soon discarded.

"The next system used was the collection of the fare from each passenger through to his destination and registration on a portable register, once for each 5 cents collected. This system was in effect until March 1, 1902, at which time the Ohmer register was installed on all cars. At that time this register took care of six classes of fares, viz., 5-cent, 10-cent, 15-cent, 20-cent, cash fare receipts and passes. Conductors issued cash fare receipts for all fares above 20 cents. Agencies were later established and tickets were placed on sale. This necessitated some changes in the register and was followed by other changes from time to time, due to improvements in the device itself, until at the present time we are using the latest model, which takes care of any fare from 5 cents to $1.50, our largest fare for any single collection being $1.45. All tickets are registered according to their one-way value.

"The merit system is used, a percentage list showing the standing of the men being furnished monthly to the division superintendents at the various terminal points, who advise them of their standing and administer the proper discipline for unsatisfactory grades. Secret inspection has also been found a necessary adjunct of mechanical safeguards.

"In an effort to educate the public to buy tickets, this company posted notices in all ticket offices some months ago, which read, 'Buy tickets before boarding cars.' Just what results were realized from these notices I am unable to state, but there is no doubt as to the small expense being fully justified.

"In my opinion the greatest progress toward safeguarding fare collections can be made in educating the public to buy tickets."

ILLINOIS TRACTION SYSTEM

B. E. Bramble, general auditor Illinois Traction System, outlines his ideas as follows:

"This topic is perhaps the cause of more thought and worry by officials of all roads than any other. Different ideas have been used by all companies with which I have come in contact in order to try to minimize the amount of revenue which unfortunately does not come into the treasury of the company. The many discussions that I have been in usually close with the same old story, that people do not believe it is possible to get all the revenues but must work toward holding down the amount lost as much as possible. I have given this subject a great deal of thought and feel convinced that theoretically the following idea would work to advantage:

"Tickets, mileage strips, transfers, stickers and other forms of transportation are to a railway as merchandise itself is to a merchant or industry of any kind, i. e., they have the value and represent what the company has to sell. This being the case, in my mind they should be dealt with as dollars and cents. Each ticket or form of transportation should have printed on it the actual value to the company, and the conductors in lifting this transportation should register the money value of these tickets collected, either through a concealed register or concealed hand duplex box. This would leave only the cash fares and passes still to be accounted for. All tickets would show the destination and points between which the passengers traveled, as would the passes. In the collection of the cash fares there would be a record either through a conductor's report and a cash fare register or through the tearing of the concealed duplex of the money collected; the duplex should show the point of origin and the destination of the passenger.

"In the auditor's office the value of all tickets in dollars and cents, plus the cash fares collected, represents the train earnings, a feature which every successful company should follow closely. By deducting the value of the tickets from the total the auditor would arrive at his charge against the conductor for the daily cash; and, through knowing the point of origin and destination of all the passengers on each train, one would be enabled to check or verify any inspector's report of this train as to the number of passengers boarding at each station and leaving the train at each station. This method of inspection and report seems to be the most complete to enable officials to know whether the conductor is turning in all his collections. By keeping each conductor's turn-in intact it is possible to call him in and show him his own work as against the inspector's report."

CONNECTICUT VALLEY STREET RAILWAY

D. P. Abercrombie, Jr., clerk and treasurer Connecticut Valley Street Railway, writes as follows:

"I believe that the largest factor in safeguarding the passenger revenue is the personnel of the employees who take up the fares and, while I appreciate that in a larger system the personal equation is not as much of a factor as it is with us, I belive that very careful consideration should be given prior to the employment of men for the position of conductors.

"From my observation, the ordinary type of car register where all kinds of fares are registered is, of course, easily subject to criticism, and with the adoption of more elaborate types, as advocated by the Ohmer company, I am not familiar enough to express a definite opinion. In our office accounting we analyze the conductors' sheets very carefully and check our volume of business each day against the difference in totals of the total registers."

MOBILE, ALA.

M. W. Glover, secretary and auditor Mobile Light & Railroad Company, expresses the following views:

"The subject is one of the most important matters now occupying the attention of officials. The following observations refer particularly to city operation.

"The fact that over 70 per cent of the new cars ordered for city service during the past year provide for the collection of fares on the platform shows this type of car is fast becoming the standard for city operation, and any system devised for improving the present methods of collecting and accounting for fares must be adapted to the pay-on-platform type of car. Many city lines have adopted this system of fare collection and are remodeling their old equipment to meet the requirements, and in this way the public is being educated to have fares ready and to pay on entering the car. The many advantages of the prepayment system of fare collection are so apparent that it is needless to mention them here.

"Accepting the prepayment system as the best so far devised, the only pertinent question is: What system of fare collection is the best? The fare boxes with locked compartments, inaccessible to the conductor, have proved unsatisfactory. Their use requires a vast amount of change to be furnished to conductors, and additional accounting results therefrom. As the contents of the box are not counted in the presence of the conductor, this leaves a question of veracity between the conductor and the money counter when any difference is discovered. Mutilated or counterfeit coins when placed in the box cannot be properly examined by the conductor, and therefore the company cannot require him to make good such coins, as he has no access to them. It requires a large increase in the force of money counters to handle the receipts from these boxes, and, in fact, there seems to be no good reason for desiring a box of this character.

"The registering fare box which gives the conductor access to the money after registration seems to be superior to any other form of box. Loss through mutilated and counterfeit coins is avoided, as they can be returned to passengers and good coins obtained. It is not necessary to supply change to conductors and the expense of accounting and additional money counters is reduced.

"It is just as important to safeguard tickets as cash fares, and a fare box should handle both tickets and cash. Another item to be considered is the cost of maintenance, and this can be determined only by experience. While the fare box is an important adjunct to prepayment operation, proper accounting for fares collected requires an additional check which can be provided by the car register. This register may be operated by a foot ringing device, thus giving the conductor the use of both hands for operating doors, making change, issuing transfers, accepting and examining transfers, etc.

"The use of the registering fare box alone for registration of the fares is not satisfactory, and 'cash fares' and all 'other fares' should be recorded on the car register to enable inspectors or others to check properly the load on a car at any time. At first glance it might be thought useless to provide a double check system on fare collections, but actual practice shows this system to be the most efficient yet devised for properly accounting for all fares.

"In order that any system may prove a success the education of trainmen must not be overlooked. Motormen as well as conductors should have the necessary instructions to enable them to handle properly the system to the satisfaction of the public as well as the company. Public opinion has delayed many a reform simply because some trainmen had not been properly instructed in the operation of the system in use. To please the public must be considered a part of the duty of each employee.

"After extensive investigation, this company adopted the Johnson registering fare box, handling both 'cash' and 'tickets,' and the International cash register, showing both 'cash' and 'other fares,' and this system of collecting and accounting for fares has worked in a most satisfactory manner. The Johnson fare box registers in fares or in dollars and cents, as desired.

"The car register is operated by a foot ringing device, enabling the conductor to use both hands for other purposes and, as the fare box is self-registering, it imposes no extra work on the conductor; in fact, the use of the fare box lessens his work, as 85 per cent of the passengers have the exact fare or tickets which are deposited in the box, and the conductor has to handle only 15 per cent of the fares, where formerly he handled 100 per cent.

"The double-check system, while causing a small increase in accounting, more than pays for itself. From an accounting standard, one of the best methods of accounting for fares collected is provided by the Ohmer fare register equipped for prepayment cars. This register provides a printed record of each class of fares collected and saves much work in the accounting office. The Ohmer register may be used with or without a fare box, as desired, and for city operation a combination of the Johnson registering fare box and the Ohmer fare register would be 'hard to beat' in more than one sense."

PORTLAND, ORE.

C. N. Huggins, treasurer Portland Railway, Light & Power Company, said:

"After using fare boxes for several years we abandoned them entirely. We use double-end pay-as-you-enter cars, with Ohmer registers arranged for cash fares, tickets and transfers, separately.

"Beginning with the introduction of this type of car and continuing for about three years, we used four-compartment non-registering fare boxes, but about a year and a half ago these were removed for reasons which all users will readily comprehend. We experimented in a limited way with the registering box, but as this device offers no adequate protection against transfer manipulation, we have not felt any keen interest in it.

"We use the merit system and pay special attention to thorough inspection, using our own staff of men almost exclusively. We seek to educate our men in proficiency and endeavor to build up in their minds the principles of fair play and co-operation. They have knowledge of our constant oversight of the work and of the fact that we are as free with compliments as with reprimands. Experience thus far has justified the confidence placed in our employees, and it is rarely that we find any irregularities in the handling of fares. So long as the present satisfactory conditions continue we feel no need of any change."

TRANSPORTATION OF FREIGHT

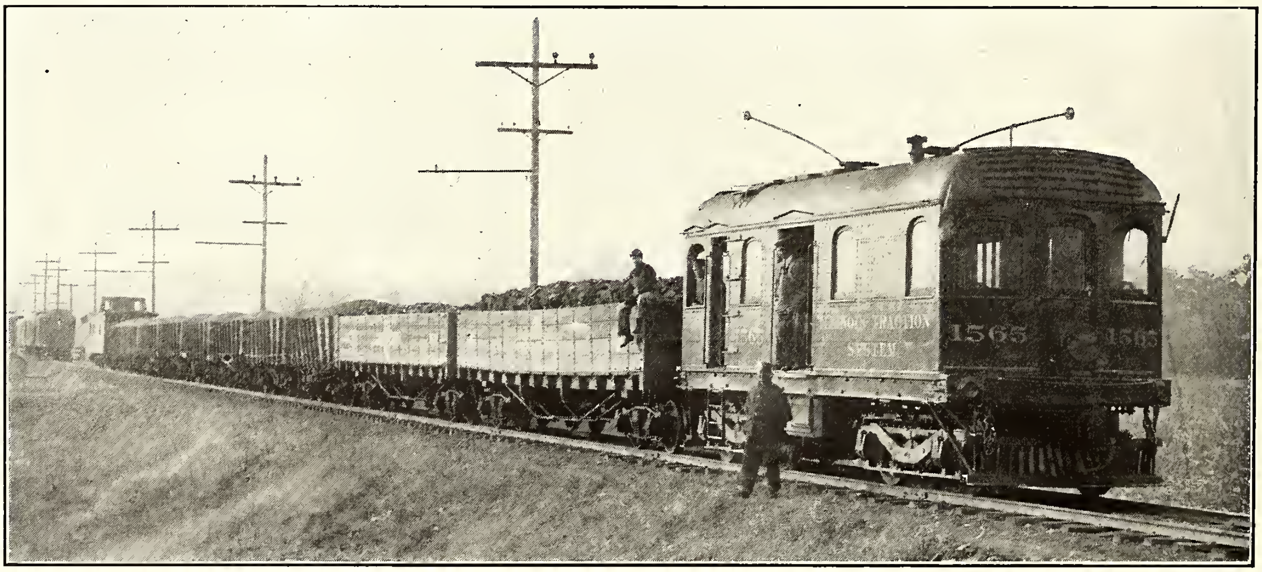
WHEN interurban electric railways began to transport freight in a modest way a little more than a decade ago, the steam railroad men in the territories traversed were inclined to regard their competition as of no importance. But as the traffic on the electric roads grew this complacent attitude gave place, at least in certain instances, to one of keen business rivalry, and every obstacle was placed in the way of the extension of the freight facilities of the electric roads. Since then, however, these same steam railway men in general have come to realize that the interurban railway, while a competitor in a small way, has created a new class of freight and express business which the steam road is unable to handle profitably.

West of the Mississippi River many steam road traffic departments have changed their attitude toward electric roads, and a general interchange of traffic is now in force. In a number of instances electric railroads are not only making deliveries and originating freight for foreign lines in their own territory but also participate in the freight revenue from through carload business where they are in a position to offer a short haul to destination. In Illinois this change of attitude is also apparent. Some of the larger electric roads are now members of the American Railway Association as well as of the state freight committee, and they are parties to all freight tariffs and participate in joint rates with all steam roads. In the Central and Eastern States, however, as well as in the Far West, there has been practically no change in the attitude of the steam roads. In some districts freight associations appear to have an unwritten understanding which prohibits the steam roads from entering into negotiations with the electric lines for the interchange of freight. This feeling does not exist with a number of the smaller steam roads, as apparently they do not feel that there is much to be gained by adhering to this policy. They are only awaiting some legitimate excuse to recognize traction lines as common carriers entitled to through rates, divisions and interchange of equipment.

In Ohio reciprocal relations may be brought about by the passage of a law forcing interchange of freight between all common carriers, but in Indiana and other states where such a law exists its enforcement devolves upon the shippers.

In a number of instances interurban railways in the pursuit of interchange contracts with steam roads have been too aggressive, believing that the issue should be forced and brought to a head in a short period of time, when in reality a systematic campaign of education would have accomplished the desired result. Others have realized the error of this procedure from the start and have made little or no effort to court relations with the steam road carriers, leaving the problem to be solved by the shippers. The latter method has been of educational value to the steam road traffic managers, and they now feel that electric roads are not attempting to enter their field of activities but intend to operate a purely local freight service and do such interline business as their connections with other electric lines will permit.

Quick delivery of freight is a class of competition which the steam road cannot meet. At the same time, it is a service which tends to develop rapidly the territories which it serves. As the communities grow through this means, the steam road is certain to share in the long haul and bulk freight business. Thus the electric road has been instrumental in creating traffic in which both may participate and prosper alike. Fundamentally, the



Standard Coal Train with Latest Type of Locomotive Adopted by Illinois Traction System

electric road consists of quick-moving small units and the steam road of slow-moving large units. These qualities put each in a distinct class, and each meets certain demands of shippers in this commercial age where economy and facility go hand in hand. Each offers a special class of service which, regardless of competition, will receive its due proportion of freight traffic.

Another condition which has tended to eliminate electric roads from interchange relations with steam roads has been their lack of freight-handling facilities, such as warehouses, trackage and equipment. Primarily interurban roads were built to transport passengers, but the frequent service they render has forced them to a greater or less extent into the handling of freight for suburban and urban communities. Small urban stores or shops do not want to carry a large stock, and it is for their interest to wait until the last minute before placing an order for a new supply. Hence an opportunity to obtain delivery of freight or merchandise in any quantity within twenty-four hours means for the small store or shop less capital invested in stock, less insurance and less storage charges than if it had to depend on steam road deliveries.

The chief obstacle to a continued increase in this class of business now on many roads is not the amount of new business in sight but the physical difficulties of expansion. In a great many cities the location of interurban passenger and freight terminals has rapidly increased real estate values until adjoining property is now held at prices prohibitive for freight terminal extension. The fact, too, that electric railways operate over public streets offers an opportunity for city administrations to demand concessions when ordinances authorizing the installation of new tracks leading from the public street into a proposed freight terminal are sought. As a direct result of this in many instances, freight terminals have not been enlarged even to meet existing traffic requirements, as the cost of installation and concessions would not be warranted by the probable increased revenue.

Shortage in rolling stock, or the fact that electric lines do not care to equip their lines to handle properly an interchange of bulk freight, also has been a handicap to them in the development of their freight business, especially that of a steam road interchange character. But few of them offer exclusive delivery or receipt of freight from industries which are not already served by steam roads, so that this makes their outbound traffic about ten times as large as their inbound business. It requires but little time to compute the result of a general interchange contract with only a sufficient number of cars to handle the local traffic. In fact, general interchange has been attempted by some electric roads which, after being deprived of most of their freight equipment, found it necessary to cut off steam road relations until new cars could be purchased or their own returned from foreign lines. The only possible way to work this out satisfactorily is for the electric roads to transfer all freight at junction points or else make arrangements with the steam roads whereby the foreign line deliveries are made in foreign cars. Both of these methods are in use on a number of electric roads throughout the country.

Joint Freight Terminal for Interurban Lines at Indianapolis, Ind.

A careful study of the relations of steam and electric roads at the present time, with a view of determining what the possible future relations may be, points very strongly toward the conduct by the electric roads of a purely local freight and express business. To operate long through freight trains during the day, when the frequent passenger service is on the line, only adds to the hazard of passenger train operation and materially delays one or the other class of traffic. A better plan, in the opinion of many managers, is to confine the freight traffic to small trains, which may readily be operated between passenger trains during the day, or else to limit the haul to such an extent as to make it possible to handle all freight traffic during the night time, when the passenger trains are practically all off the line. An important advantage urged in favor of night operation is that it not only assists in raising the sag in the power house load curve but increases the gross business without adding materially to the fixed charges.

Another stumbling block which prevents interurban roads from handling all classes of freight, and thus carrying on general interchange with steam roads, is franchise limitations. Reports from a large number of interurban roads operating throughout the country show that very many of them are restricted to trains of limited lengths and that, in many instances, the operation of standard steam road freight cars on city streets is prohibited. Since the beginning of the era of interurban roads this restriction has materially interfered with the handling of freight traffic.

In negotiating for franchises in virgin territory, however, attempts have been made to eliminate these restrictions from the franchise agreement. But it was found that the old idea still prevailed and that the communities through which the line proposed to build would not permit the operation of a general freight business. The only solution of this problem seems to lie in the construction of electric lines around villages or through them on a private right-of-way. Passenger lines may be extended into the business centers of the larger cities and belt lines for the handling of through freight and passenger business may be built around these larger traffic centers. Some electric roads have solved the problem in this manner.

Certain managers have no objection to restrictions of the kind mentioned in regard to the class of freight to be hauled through city streets. They believe that freight traffic should be confined entirely to what may be termed dispatch freight, for which a charge can be made approximately twice that of first-class freight rates. Although it may appear that this dispatch freight business offers a certain amount of competition to the old-line express companies which now are largely operating over interurban lines, experience has shown that these companies have no objection to it.

A marked difference between the steam and electric railway freight business is that on the electric road the passenger traffic is the most important and the freight business may be considered a by-product, while on the steam line the passenger business may be considered to be the by-product. In either case, however, it assists in developing the territory to conduct both classes of business, even if one seems practically to be unprofitable. Thus, there is no doubt that the tremendous passenger development on the electric lines about Los Angeles is in large part due to the attention which the Pacific Electric Railway Company has given to the freight business, although it is doubtful how much of it is directly profitable.

Unloading Shipments in Street Opposite Station at Quakertown, Lehigh Valley Transit Company

POSSIBILITY OF INCREASING INTERURBAN FREIGHT RATES

The Detroit United Railway, having engaged in a little pioneering, has demonstrated that it is possible for interurban roads to increase their freight rates in many instances without materially affecting the quantity of freight handled. Until recently the rates on a 10-gal. can of milk or cream over the different divisions of the Detroit United Railway entering Detroit have been variable. In one instance 6 cents was charged for a 10-gal.

can for a distance of 12 miles, on another 8 cents was charged for a 10-gal. can for a distance of 18 miles, and on another a rate of 10 cents per 10-gal. can was made for a distance of 78 miles. Incidentally it might be stated that these rates had been in existence for several years, having been applied on the various divisions by the predecessors of the Detroit United Railway before they had been purchased and merged into a single system.

Inconsistencies of this character made it impossible for the company to justify the rates when comparisons were made by the milk and cream shippers on the various divisions. To remove this apparent discrimination, the general express and freight department prepared a new tariff based on a zone system scale of rates, one rate applying on milk and one on cream. The suggestion for such a move came from the Interstate Commerce Commission, which at that time was hearing a case in which one or more of the steam roads were involved. The final result of this case was that that body made a rate of 20 cents per 10-gal. can for a haul of 1 mile to 25 miles on either milk or cream and a rate of 21 cents per 10-gal. can for a haul of from 26 to 30 miles, with a graduated scale for greater distances. Rates also were specified for a 5-gal. and an 8-gal. can based on a prorating of the 10-gal. can charge.

These rates were immediately adopted by the Detroit United Railway, and not long after, upon complaint of several shippers, a request was made by the Michigan Railroad Commission to suspend their application until a hearing for the interested parties could be held. This request was observed as it was the desire of the Detroit United Railway to co-operate with the commission and to place before it the inconsistencies with which the company had to contend in the establishment of traffic charges. It might be mentioned that it was only a short time before this case came up that the Michigan Railroad Commission had disposed of a similar case in which the steam roads of Michigan were involved. In this case the commission practically adopted the same rates as those ordered by the Interstate Commission, the only difference being that the Michigan commission made a rate of 15 cents on a 10-gal. can of milk and 20 cents on a 10-gal. can of cream for from 1 mile to 25 miles, with a graduated scale for greater distances.

The differences between the shippers and the Detroit United Railway were heard in detail, and after a period of two or three months the Michigan commission rendered its decision. It provided that the rates for interurban roads should not exceed 12 cents per 10-gal. can for either milk or cream for 1 mile to 20 miles, and 15 cents per can for a distance of from 21 to 30 miles, the empties to be returned to the point of shipment free. The Detroit United Railway then gave notice to the shippers and the Michigan Railroad Commission that the expense of carrying this commodity was such as to prohibit compliance with the order. It also asked that the order be suspended so that further evidence could be produced to substantiate this statement. The commission acceded to this request, and after more than a year, during which several meetings were held and information submitted, the Michigan Railroad Commission rescinded its former order and adopted the following scale for interurban roads: 15 cents per 10-gal. can for a distance of 1 mile to 30 miles on either milk or cream and 22 cents for 31 to 35 miles, with a graduated scale beyond similar to that in effect under the order issued by the Interstate Commerce Commission.

Milk Shipments Unloaded in Front of a Creamery on the Lines of the Cleveland, Southwestern & Columbus Railway

HIGHER RATES DESIRABLE

Several electric roads have filed exceptions to the official classifications, which were intended either to eliminate a portion of the undesirable freight or place it in a class where the revenue returned would make it profitable for the company to handle it. These exceptions to the official classification have been adopted without obtaining permission of the Railroad Commission, which usually does not object to or reject a tariff so long as the rates are published and filed. If complaint comes from a shipper, he must present convincing evidence showing that the rates should be reduced; consequently very few complaints are filed. A fact which justifies a higher rate for electric service than for steam service is that, generally speaking, deliveries are made with the same dispatch as old-line express companies. The flexibility, frequency and dispatch of the service which can be rendered by electric lines under proper conditions, and for a great number of commodities, entitles them to a higher revenue, and they should have a separate classification.

Unloading Milk at Cleveland, Southwestern & Columbus Terminal Station in Cleveland

Under the list of exceptions to the official classification shown in an electric joint class tariff and class rates between certain stations, filed with the Railroad Commission of Michigan by the Detroit United Railway Company, this statement appears: "All shipments of a fragile or perishable nature can be accepted at owner's risk only and must be so receipted for." This list of exceptions also includes a large number of items, some of which will not be accepted at all for shipment; on others the regular rate is applied with a minimum charge, while on some commodities a higher rate is applied than that in the official classification. Another requirement under the list

Views of Elevator and of Farmers Shipping Corn, Illinois Traction System of exceptions, which brings with it a reduction of claims, is a description of how certain shipments must be crated or wrapped before they are accepted for transportation. In each of these instances the change in the wrapping and crating specifications from the official classification is based on the experience which this company has had in handling the commodities named.

ORGANIZATION OF THE TRAFFIC DEPARTMENT

The size and character of a freight traffic department organization depends upon the quantity of business handled as well as the method in which it is handled. So far as freight and express traffic are concerned, the electric roads of the United States divide themselves into six different classes. The first includes the purely passenger service lines. The second are those lines on which an independent express company operates on a percentage basis and offers a wagon collection and delivery service at rates slightly above those fixed by the steam roads. The third condition is where several electric roads enter into an agreement whereby an express package company is organized and operated as a separate department, with a wagon collection and delivery service and rates practically equal to those of old-line express companies, each railway company sharing in the net revenue in proportion to the business it handles for the express company. The fourth class includes those roads operating a less-than-carload and carload freight business at steam road rates, with a dispatch freight service at approximately twice first-class rates. The fifth class are those roads operating a general freight and express business in all classes both less-than-carload and carload, with interchange relations, carrying through rates with steam roads but exclusive of a through freight business, and the sixth class embraces a few lines operating a general freight business on exactly the same basis as steam roads, being accepted as such. Each of these classes, except those transporting only passengers or operating their express and freight business as an entirely separate department, requires a special kind of organization to handle the freight traffic.

For electric roads operating a strictly local freight and express business the ideal organization would include a general freight and passenger agent in charge of the proper handling of freight to and from cars as well as the stimulation of business. It seems unnecessary in defining his duties to separate the freight from the passenger business, except in so far as routine matters are concerned, and these may be handled by the clerical force. This general freight and passenger agent should be the court of last resort as regards all traffic matters and should direct the movement of all division agents, issue all tariffs and advertising matter and be in close touch with all industrial and trade associations.

Being the recognized head, he should familiarize himself with the transportation department in so far as the handling of regular and special trains over the line is concerned. His general acquaintance with the shippers as well as with the methods of billing and handling in transit should enable him to give excellent counsel to claim investigators, who may work either under his supervision or under that of the auditing department.

Interior of Joint Freight Station at Indianapolis, Ind.

The general freight and passenger agent should appoint a sufficient number of district freight and passenger agents properly to cover the territory. These agents should cultivate their respective districts intensely. They should become personally acquainted with the larger shippers throughout the territory and have a general knowledge of all prospects. The duties of these district agents should include a certain amount of original work in the way of solicitation, but in the most part they should act in an advisory capacity to the local or way station agents. Usually, the way station agent knows his public's whims and fancies, and, if the right man has been selected, he is better able to deal with them. All matters regarding the handling and delivering of freight through the warehouse and way stations should come under the district agents' supervision through the local agent. The fact that their jurisdiction includes a number of station agents permits of comparison of their relative efficiencies, with a final result that all may be brought up to the same standard so far as freight traffic is concerned.

Little need be said regarding the clerical help in the general agent's office, except that it should be sufficient to handle all the details of departmental work promptly and efficiently. Too much stress cannot be laid on the care which should be exercised in writing a letter to a shipper in reply to either complaints or inquiries. It is common to judge a man by the character of letter he writes, and the same rule applies to a railroad company. In a number of instances ill-advised composition in a railroad freight office has resulted in the loss of shippers, especially those in the territory of a competitor.

ment of a freight business. That is to say, if he is enabled to make deliveries and obtain his receipts promptly, and if there are paved driveways to the freight house doors and canopies over them so that he is protected when loading or unloading freight in bad weather, much may be accomplished. In many instances it is practically impossible for the representative of the manufacturer or shipper to call personally to investigate certain complaints on the part of his teamster and he is forced to accept what is told him as fact.

The necessity for a certain amount of tact in employees dealing directly with the teamsters or shippers is not confined to the warehouse foreman. It should be required from everyone in the warehouse organization who has dealings with the public. This is especially true of receiving clerks and checkers, as well as of the cashier who supervises the credit list.

Team Side of Receiving Shed at Los Angeles Freight Terminal, Pacific Electric Railway

Where the quantity of freight and express business warrants, the best practice is to appoint a local freight and express agent in addition to a passenger agent. This is an era of specialization, and the man who is properly equipped to discuss matters with his patrons produces far better results than one who has so many things and subjects to handle that he is capable of discussing none intelligently. At the larger stations, besides the agent and clerical help, the force usually includes a day and a night foreman, who have supervision over the checkers, receiving clerks and truckers and report direct to the local agent. The warehouse foreman should be a man with sufficient executive ability to handle the men under his charge and should also be a man who can handle teamsters tactfully. One not familiar with the trials and tribulations of a warehouse foreman cannot know how important it is that this particular person should possess tact. Finally, the treatment accorded to the teamster of the shipper and the facilities afforded to him are important factors in develop-

The warehouse floors should be sufficiently large so that the receiving doorways may be kept clear, thus obviating congestion and enabling teamsters to deliver their shipments promptly. Certain rules strictly adhered to will bring about this result, such as setting aside doors on the team side for receiving shipments for certain destinations, or requiring teamsters to unload their freight on the warehouse floor with the destination marking in plain sight so that the receiving clerk may check the way bills promptly and receipt for them.

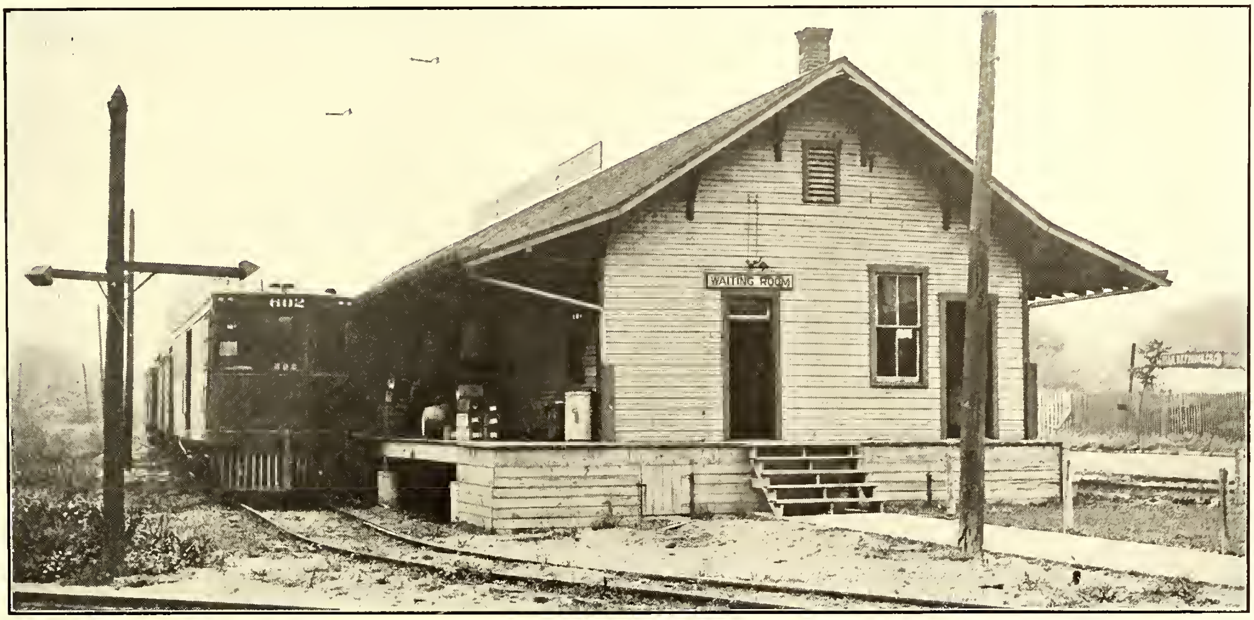
Too much stress cannot be laid on the care to be taken when freight is moved through the warehouse into the cars. As a general rule, when the men are paid less than the scale effective in steam railroad warehouses, a large number of over and short shipments as well as damaged merchandise will result. This not only makes a dissatisfied customer but creates claims which, in a great many instances, are much larger than the freight revenue collected. The addition of a stevedore or an experienced man in loading shipments into the cars, as regards both station order and the quality of the packages, is an important factor in reducing the quantity and amount of claims. If the quantity of business handled is not too large, the local agent may supervise the loading of freight himself. Being held responsible for the traffic handled through his warehouse, he will take much more interest than the ordinary checker or trucker who does not assume any responsibility.

In general, the way station agent reports to all departments so far as matters coming under the supervision of each is concerned. In other words, he is the football of all departments of the railroad, just as he is on a steam road. In all instances he should, if possible, be equal in ability to the steam road agent in the same locality. It is useless to expect first quality results from an inferior man. The agent for each station should not only be competent to handle the business already there, but he should also be capable of developing into a man who will handle the future increase in freight traffic either from solicitation or through the natural increase in the business in a growing community.

Usually at the way stations, where the company either owns or rents its station building, the agents receive a salary. But at those stations where the business is insufficient to warrant the payment of a fixed salary a storekeeper whose place of business is near the track is appointed agent and receives a commission based on the quantity of business handled. The fact that the way station agent's business is almost wholly confined to the handling of freight and passenger traffic necessitates smaller salaries than those paid on steam roads where the agent also must be a telegraph operator.

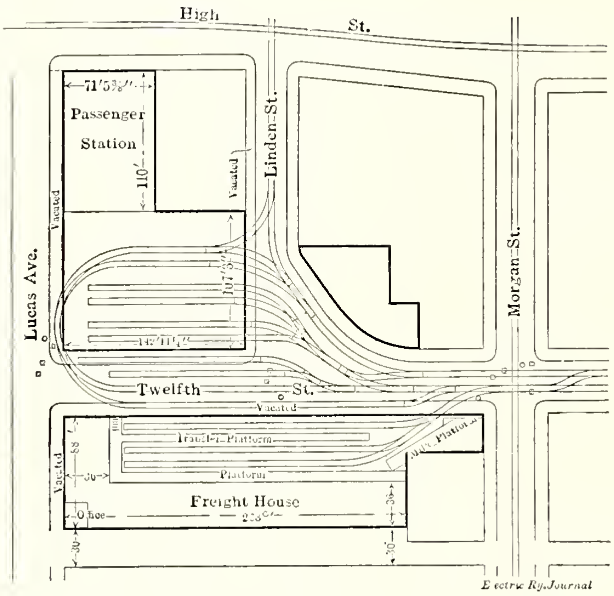
Many electric roads have made it a rule to combine the duties of substation attendant, where possible, with those of way station agent. Unless the quantity of business handled is small and there is a lack of competition, this arrangement is not very satisfactory. The agent's first duty is that of an attendant in the substation. Although it may not be necessary for him to be on duty at all times, the fact that an emergency may arise at any instant makes his constant presence imperative. In view of this, it is impossible to expect him to solicit freight or make collections or adjustments away from his station unless he has an assistant. With the addition of a helper to the substation agent this arrangement is quite satisfactory.

Some roads have devised novel methods of meeting competition and providing way station agents where the business does not warrant the building of a station or the maintenance of sufficient help to operate it. Thus, to meet a competing collection and delivery service, it has been found practicable for the local agent to be a local teamster who makes it his business to meet all trains and make collections and deliveries of freight. In fact, he acts as the way station agent in every sense of the word except that he does not have a station and has nothing to do with the sale of tickets to passengers. As a rule, the collection and delivery service which he performs for the traction company does not require his entire time, and he is able to carry on a general teaming business in addition. Where considerable care has been exercised in the selection of the teamster to act as local agent, it has worked out quite satisfactorily so far as the traction company is concerned.



Freight House and Transfer Station of Union Traction Company of Indiana, at Anderson, the Junction of Three Divisions

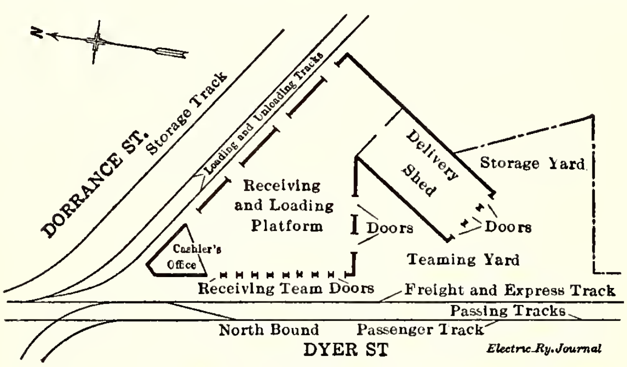
As the quantity of freight traffic increases and the simple organization—namely, the general freight and passenger agent, assisted by district freight and passenger agents—is not sufficient to handle the details coming to the traffic department, additional help must be taken into the organization to meet the requirements. Usually the first commodity to receive special attention is the dairy traffic. The dairy traffic agent usually does not confine his time wholly to caring for his shippers and consignees, but when not otherwise engaged he calls the farmers together in various communities and organizes central milk stations, and from time to time he arranges for lectures by experts along the line of increasing efficiency in producing dairy products.



St. Louis Freight Terminal, Illinois Traction System

The next step in an organization appears to be the adding of an industrial agent to the regular organization. His duties may be directed in several channels, but they are usually confined to organizing the farmers of rural communities into elevator companies, to interesting manufacturers to locate factories on interurban lines, or to inducing those already near the right-of-way to have industrial tracks built to their works.

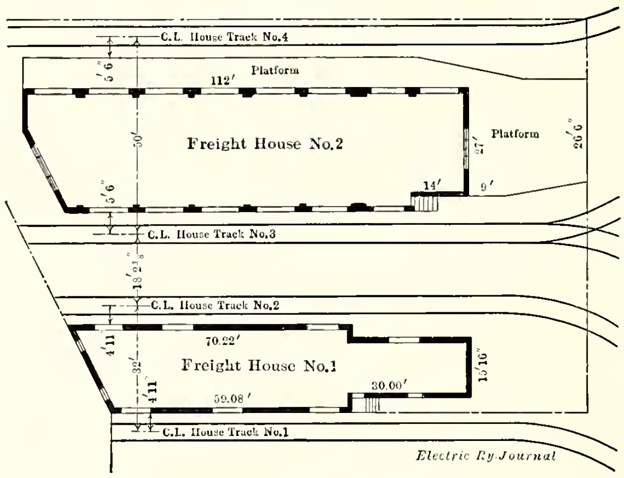
Recently there has been considerable discussion as to the employment of a soliciting freight agent covering a wide territory. There can be little doubt as to the value



Plan of Dyer Street Freight House of the Rhode Island Company

of such a man, if he makes it his business to become personally acquainted with the larger shippers and confines his efforts to soliciting their business. There is some question, however, as to his ability to increase less-than-carload business in local communities. Some traffic heads are of the opinion that if the way station agent were to have an assistant he might have sufficient time to make outside solicitation, or that if the personnel were raised by increasing the agents' salaries, it would attract men with more intelligence and energy for obtaining the desired results. Generally, the local agent is better acquainted with his community than an outside man, and, like the trainman, the local agent is the personal representative of the traction company and it is judged according to the standard he sets.

With an increase in the quantity of business, it becomes necessary to enlarge the department for investigating and settling freight claims. As already mentioned, where the number of the claims is small they may readily be handled by the auditing department or under the supervision of the general freight and express agent. But when a large volume of freight traffic is handled best results may be obtained by organizing a separate department, the duties of which are confined to the disposing of claims. The head of this department—namely, the freight claim agent—should report to the general superintendent or general manager, because the results of his investigations often



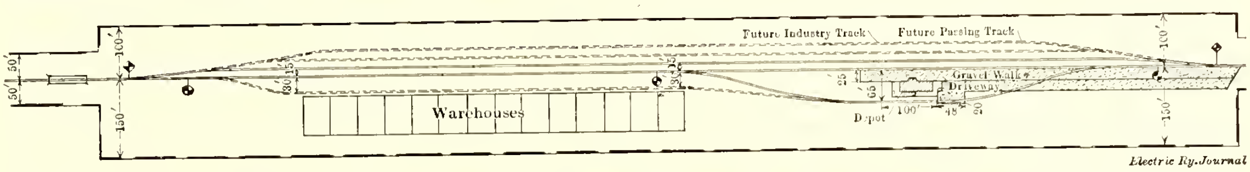
Fort Wayne Terminal of Fort Wayne & Northern Indiana

require that employees in other departments than the traffic be reprimanded.

The freight claim agent's organization should include a sufficient number of investigators to expedite the handling of claims through correspondence or personal investigation. In order that investigation may be started in the shortest possible time after the filing of a claim, the local and way station agents should report all matters coming under the jurisdiction of the claim department direct to the claim agent, sending a copy of the report to the head of the traffic department.

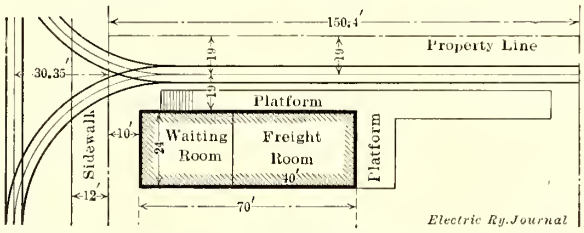
FREIGHT-HANDLING FACILITIES

Freight terminal trackage and warehouse arrangements are important factors in the expeditious handling of freight, both from the warehouse and the transportation standpoints. In most instances, electric railways have used excellent judgment in the location of their freight terminals, but many have failed to give proper consideration to the possible future development of the business, having purchased sites which would take care only of immediate demands. As a result of this short-sightedness, property in the vicinity has rapidly enhanced in value until it is now held at prices prohibitive of the purchase of land for additional freight-handling facilities. Too much care cannot be exercised in estimating future demands at long range and making purchases accordingly. Undoubtedly, the general rule will hold in almost all cases, namely, that property purchased and not required at the time for freight terminals will increase in value to such an extent as to equal the charges necessary to carry it until it is required.



Oregon Electric Railway—Plan of Typical Way Station Grounds, Showing Freight Sidings and Warehouses

The wide experience which steam roads have had in handling freight has resulted in the adoption of a design which provides for a long warehouse 36 ft. to 50 ft. in width, with numerous doors from 8 ft. to 10 ft. in width on the team side and doors arranged on the track or car side so that cars may be set with their doors opposite those in the warehouse.



Typical Way Station Layout, Illinois Traction System

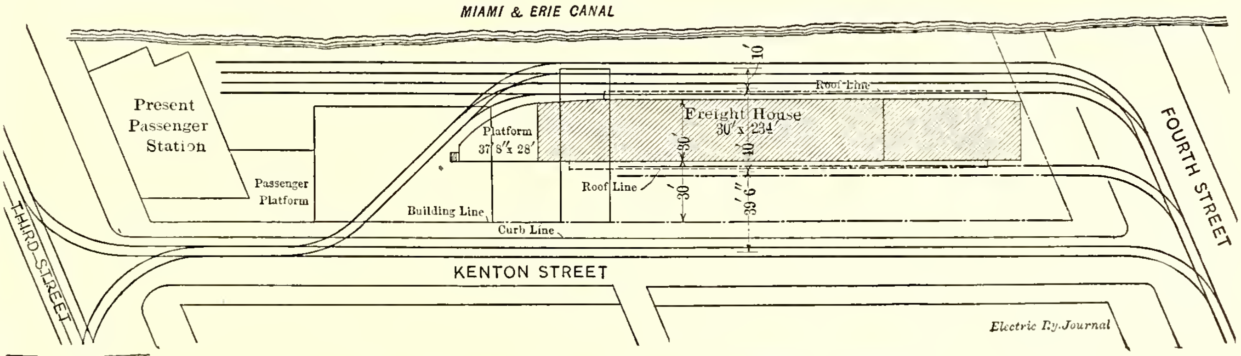
The driveway on the team side should be at least 30 ft. wide, or wider where possible, and paved with brick, wood block or granite block so that teams will not be stalled, thus causing congestion in the driveways and annoyance to the teamsters.

Careful consideration of the elevation of a freight-house floor above the driveway has resulted in the general adoption of a height of from 3 ft. 6 in. to 4 ft. On the track side of the warehouse as many tracks, up to four, paralleling the building should be installed as the quantity of business may require. Rather than increase the number of tracks to relieve congestion in the warehouse, it is better to extend the warehouse and the tracks to accommodate the increase in business. More than four tracks at the warehouse have been found to increase congestion rather than relieve it.

Another factor which tends to expedite the movement of less-than-carload freight from the warehouse into the cars or the reverse is the provision of a 6-ft. to 8-ft. platform on the track side between the warehouse and the first track. This arrangement permits truckers to pass out of any door and move along the platform to the car in which they propose to place the freight. A protecting awning over this platform is also advantageous in that it offers protection to the truckers and freight which is subject to damage by water. A similar projecting awning on the team side also has been adopted in many cases.

Usually it is unnecessary to provide heat in the warehouse, but a certain amount of space should be set aside and inclosed for a hot-storage room during periods of low temperature. Every warehouse should be supplied with a sufficient number of platform scales located so as to cause as little delay as possible in the movement of freight through the warehouse when weighing of shipments is necessary. Preferably these scales should be automatic, making it possible to deduct the tare by adjusting the scale. Weighing on an automatic scale is facilitated if the same type of truck is used in handling all shipments, as the tare adjustment will then remain fixed.

The arrangement of the typical way station facilities generally included a freight room adjoining the way station agent's office of sufficient size to handle the less-than-carload business and a team track for carload freight business. There is a difference of opinion as to the proper elevation of the floor in the freight room, as well as of the platforms in the open which parallel the track at way stations. Some traffic managers are of the opinion that less-than-carload freight may be handled



Location Plan of Dayton Freight House, Ohio Electric Railway more expeditiously from a platform at the track level than from one at the height of the car floor. Way station freight generally is unloaded from the main track, and if the freight-house floor and platforms are at the height of the car floor, it is necessary to truck the freight a considerable distance to the building, as the freight platform must be located away from the station building in order not to interfere with the handling of passengers. If the way station platform and freight-room floor are at the track level, as is the general practice on steam roads, freight may be unloaded from a car standing on the main track immediately in front of the building, thus permitting the shortest possible movement from the platform to the freight room.

Interior of St. Louis Freight Station, Illinois Traction System

Side tracks at way stations should always be double-end or in the form of a wye, so as to make switching unnecessary. These tracks should be so located as to make it possible to use them both as team tracks and as house tracks. Some traffic managers have decided that the house track is unnecessary at way stations, believing that, if the less-than-carload freight is sufficient to make a carload, the freight may be delivered or received to and from a car more economically than through the freight house. This eliminates one handling by the agent and assists materially in keeping down fixed charges by making small freight rooms practicable.

EXPRESS TRAIN OPERATION

The arrangement of express and freight train schedules to meet shippers' demands has received consideration on some electric roads, but operating economy usually is the governing factor in fixing schedules. A great many lines give a morning and evening delivery of less-than-carload freight shipments. Almost all roads engaged in handling shipments of milk have found it necessary to arrange their schedules to meet the demands of the consignee.

The best practice in operating through car service is to avoid all interference with the regular passenger business. Through express trains as well as bulk freight are usually moved between midnight and 5 o'clock in the morning, as the promise of an overnight delivery usually meets steam road competition.

LEASING RIGHT-OF-WAY AND BUILDING INDUSTRIAL TRACKS

Owing to the narrow right-of-way on which a great many of the older interurban lines were built, the surplus area is too small to lease a portion for industrial purposes.

Cars at Transfer Platform of St. Louis Terminal, Illinois Traction System

Some roads, however, have a sufficient width of right-of-way at various locations to make leasing possible. The method of leasing right-of-way for industrial purposes is practically the same as that practised by steam roads. Leases are made to elevator companies, retail coal dealers and the like, and the charge made for right-of-way leased is so fixed that it will represent a 6 per cent return on the valuation. Usually the life of the lease is made

Team-Side Doors, Ohio Electric Freight House at Springfield

indeterminate, the lease stating that if the company should require the property at any time it shall be cleared within ninety days after notification. There have been very few instances, however, where railroad companies have found it necessary to enforce this clause, as the location of the leased property is carefully considered before the contract is made.

One way by which a railway may stimulate freight business is to accommodate shippers by building side tracks to industries. As a general rule, sidings of this character are not constructed until the firm has been thoroughly investigated and has guaranteed to ship a certain number of cars per month or year over the railway company's lines. Until a decision was rendered recently by the Interstate Commerce Commission, it had been the custom for railway companies to furnish all labor and materials for a side track at the expense of the industry. The industry, however, was reimbursed later by a rebate of $1 or $2 per car of freight moved to or from the plant.

Team Side of Springfield Station, Ohio Electric Railway

Cars at Rough-Freight Shed, Detroit United Railway

Combination Passenger and Freight Station, Lehigh Valley Transit Company

WAGON PICK-UP AND DELIVERY

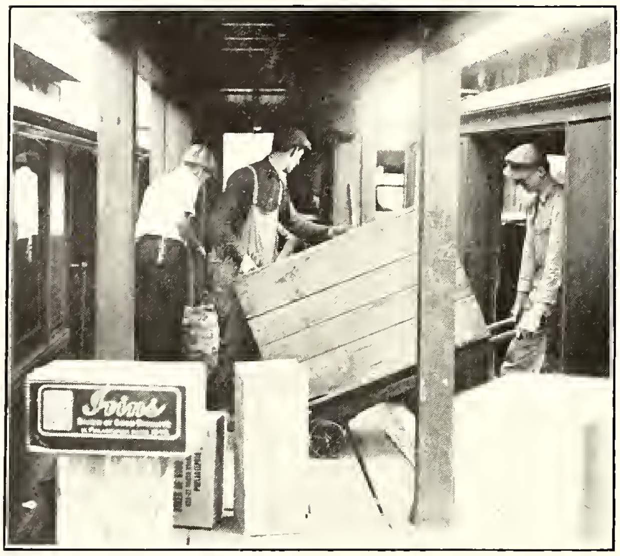
Reports from more than 100 interurban railways in the United States indicate that very few of them maintain a wagon pick-up and delivery service. Some are operating with this extra service, charging practically steam road freight rates plus an additional charge for the wagon service. There are, however, several instances where electric railway companies have transferred their entire express and freight business to an independent express and freight company which also operates a collection and delivery service, for which it collects practically old-line express rates. In general, the railway companies appear to consider the wagon pick-up and delivery service undesirable, particularly when it is handled by the company's own organization. It means an enlargment of the organization and places the electric railway in a field of transportation with which most traffic men are not familiar. In a few instances the railway company has been forced to resort to wagon collection and delivery service. These are where the franchise limitations do not permit the operation of freight cars of any type in the city streets. Hence it has become necessary to locate the freight station outside the corporate limits and collect and deliver freight by wagons.

STIMULATING EXPRESS AND FREIGHT TRAFFIC

The development of a freight business on electric lines depends largely on the same fundamentals which control freight traffic on steam roads, namely, adequate station and track facilities located as advantageously as those of competing carriers. In this commercial era shippers deal entirely on an economical basis, and only in a few instances will sentiment divert a shipment from a road offering the quickest delivery, particularly after reliability of service has been established.

Numerous forms of publicity have been used by electric roads for stimulating freight traffic, including folders, painted signs and posters, maps, etc., but in the end the real results were obtained through personal solicitation. There was a time when solicitors could bid for traffic against competing roads by reducing rates or rebating, but that method is a thing of the past. Service is everything to the shipper in this day and age, and where two competing roads are on an equal basis so far as the shipper is concerned personal contact at the proper instant usually brings results. To be in touch with the large shippers at the psychological moment is in truth the all-controlling factor when other things are equal.

Freight solicitors also must carefully scrutinize the newspapers in their territory with a view to anticipating shipments of materials for large construction jobs. Frequent personal visits of solicitation usually result in much good. Although the shipper may not have anything to route by the electric line at the time the solicitor visits him, if a convincing argument has been presented and the shipper is satisfied that the electric road can transport his freight with facility equal to other competitors, when shipments are forwarded the electric road has an equal opportunity to obtain the business.



Transfer Platform at Chestnut Hill, Lehigh Valley Transit Company

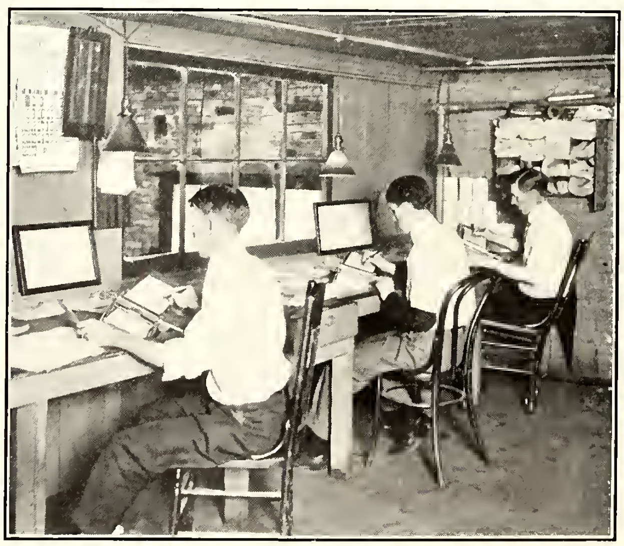
Loading Freight by Block System at Los Angeles, Pacific Electric Railway

HANDLING SHIPMENTS IN THE WAREHOUSE

Most modern practice in the methods of receiving, checking and billing less-than-carload shipments at terminal stations must of necessity conform in a general way to steam road practice. Freight offered for shipment is checked from dray to warehouse and is carefully examined as to condition and weight by comparison with the shipper's bill of lading, which, if found correct, is signed by the receiving clerk.

Some of the factors which enter into the expeditious handling of freight on the team side of the warehouse are the understanding which the local agent has with teamsters so as to bring about an orderly movement of teams through the driveways beside the warehouses and the manner in which certain doors are designated for the receipt of shipments for certain stations. Many attempts have been made to employ the latter plan on electric roads, but it is not very satisfactory. Usually teamsters do not care to wait to have their shipments received at a certain door when other doors and receiving clerks are free to relieve them. The work of the receiving clerks is greatly facilitated if teamsters are required to place their shipments on the floor with the destination markings in plain sight. The relative location of the cashier's office where the credit list records are kept and all cash is received on prepay and inbound shipments deserves careful consideration. If it is central in relation to the receiving doors on the team side, less time will be required to complete the transaction, thus enabling the dray to move away from the station quickly.

While the loading of outbound freight may appear to be a simple process, too much care cannot be exercised in placing all shipments in the cars in station order and so loading them that the fragile shipments will not be in a position to be damaged in transit. With many roads the O. S. & D. report form must be made out frequently, owing in a large measure to incompetent handling of freight from the warehouse into cars.



Preparing Unit Way Bills, Indianapolis Traction & Terminal Freight House

Two systems of billing freight to destinations are employed by the various electric roads throughout the country, namely, the individual or unit way bill and the blanket way bill. When the unit way bill is employed, a sufficient number of copies may be made to furnish the receiving agent with his receipt and expense bill, as well as those required for the forwarding agent and auditor. This reduces the amount of clerical work necessary at both receiving and delivery stations and, at the same time, permits a quicker delivery after the freight has arrived at its destination. The unit or individual way bill has been in satisfactory use on a number of electric roads where the volume of business handled is quite large, and although not used by steam roads, its general adoption by electric lines is being seriously considered. When the freight business reaches such proportions as to compare favorably with steam roads, the blanket way bill appears to give best satisfaction, as it is said to relieve the receiving clerk of the responsibility of fixing rates, these being computed by rate clerks. It also forms a simpler record of the day's business handled by each station.

Switching Various Classes of Electric and Steam Railroad Equipment at Los Angeles, Pacific Electric Railway

Double-Section Milk Platform, Detroit United Railway

PERISHABLE FREIGHT

Practically all electric lines in the freight and express business are transporting perishables of all kinds under certain restrictions. Fruits and vegetables usually are not accepted in less than carload shipments unless they are in baskets or crates fully protected with solid or slatted wood covers. Shipments of fresh meat and some fruits and vegetables are only received at a time which will permit their delivery before it is possible for the shipment to spoil in transit.

Some companies are operating a refrigerator service in conjunction with the local express but receive only long-haul shipments of perishables for shipments in these cars. Usually this service is established between certain division points where the quantity of perishable shipments is sufficient to justify the service. At the division points the perishables may be transferred to local express trains for delivery to local destinations.

A number of the Indiana lines operate a dispatch freight service which enables them to give prompt deliveries of all perishables, thus reducing the liability of claims arising for damage in transit. This dispatch freight is transported in the baggage compartments of passenger cars, and a rate approximating two to two and one-half times first-class is charged for this service. If considerable care is exercised in the handling of perishables as to time in transit and in investigating the method of bagging or crating, it is considered a desirable commodity, as it brings a high rate and is not subject to claims when transported promptly and properly.

LIVE STOCK SHIPMENTS

Owing to franchise restrictions in a number of cities, many interurban roads are not able to handle live stock shipments. Others have attempted to handle this class of traffic but have found it was necessary to provide special equipment for everything but horses or live stock in crates. Consequently many roads have abandoned further efforts to transport all classes of live stock and limit it to horses. If special rolling stock is provided to handle all classes of live stock and loading facilities such as stock chutes and pens are installed at the way stations, it becomes a profitable and very desirable class of business.

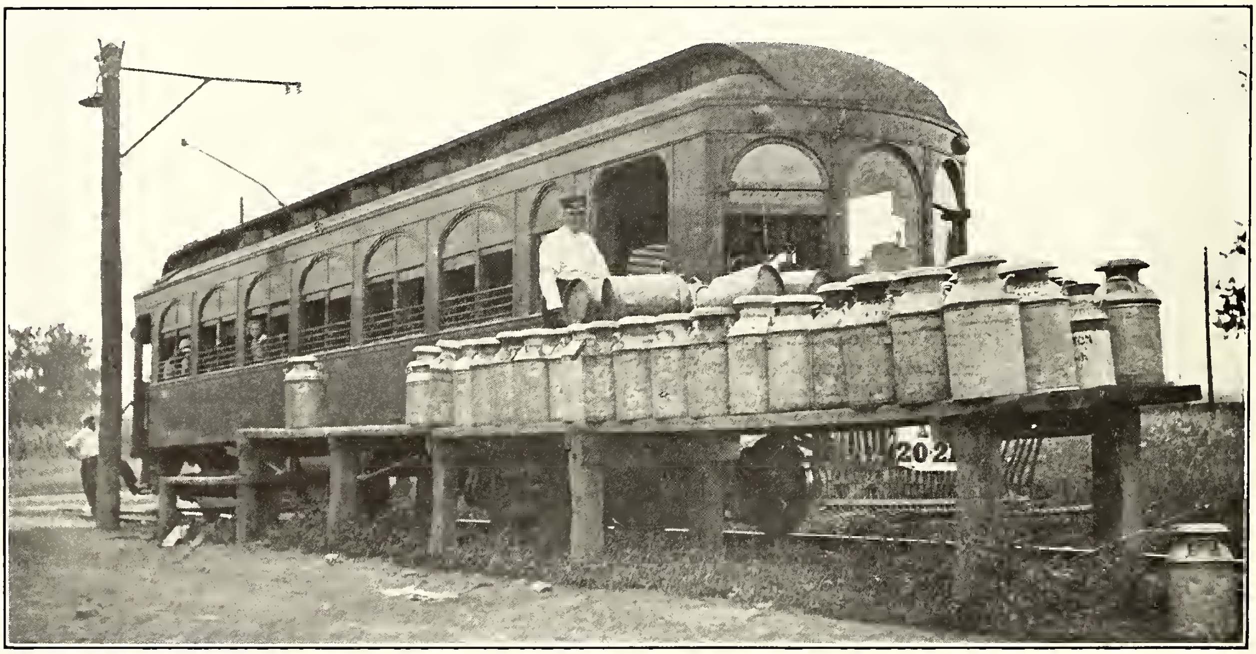
Most electric roads accepting horses for shipment have equipped themselves with inclines at the freight stations and provided side windows in the express cars so that a single or full carload of horses may be transported. These shipments are received, however, only at stations properly equipped and are delivered at destinations where the horses may be unloaded without injury. Certain electric roads have attempted to pick up stock at crossroads by employing portable stock chutes, but in some cases this method has been found impracticable, as too many injuries occurred in loading or unloading.

MILK SHIPMENTS

Most of the electric roads with terminals in large cities operate a special milk train service with trains scheduled so that milk may be picked up in the early hours of the morning and transported to destination in time for the retailers to make deliveries. In many instances this special service is operated in connection with a large milk depot to which the farmers in the surrounding territory deliver their milk to be pasteurized and cooled before shipment. Generally cans of milk are received at any point on the railway system where a platform conforming to the railway company's specifications has been built. If the business warrants, the company will furnish a milk platform; otherwise the shipper must bear the expense of constructing one conforming to the company's specifications. On many lines the quantity of milk shipped does not warrant the operation of special trains, and on divisions where this is the case the milk is picked up by the local express and passenger trains and delivered to destination.

It appears that the general rule in shipping milk on electric roads is by prepayment of the freight. Each local agent is supplied with a quantity of milk tickets, or tags, which are attached to the cans when they are left on the platform to be picked up by the train crew. Some companies require a round-trip ticket, usually in the form of a tag with an attached coupon, the latter being detached for the movement in one direction, and the rest of the tag for movement in the opposite direction. Other traction lines use a single ticket which also is attached to the can, and the return movement is made on the can initials.

As a result of difficulties experienced in making correct deliveries to consignees, a form of way bill has been provided by some companies for the protection of the conductor responsible for the milk in transit and for the protection of the company in making deliveries. As the cans are picked up at the different railway stations, the number received from each shipper is recorded on the conductor's way bill, as well as the names of consignor and consignee. Upon arrival of the milk train at destination, the consignee is required to sign for each shipment or for a number of consignments shipped to him. Some electric roads have experienced no difficulty in making correct deliveries at destination. Consequently, they adhere to the old method of permitting the going and return ticket to form the only record of shipment.



Milk Platform at Grafton, Ohio, on the Cleveland, Southwestern & Columbus Railway

CRATING AND WRAPPING

The question of properly crating and wrapping different classes of merchandise is much discussed, having received considerable attention from the General Claim Agents' Association for a number of years. Certain instructions have been issued in the official classification, and the regular shippers have learned to conform to these specifications, knowing their shipments will be refused if improperly prepared for transit.

The necessity for exercising extreme care in this particular direction, however, has not been obviated by these instructions, and it is often necessary to refuse shipments of merchandise coming from infrequent shippers. If agents and receiving clerks are advised as regards the character of crating and wrapping required for various shipments and the rules are strictly adhered to, a considerable reduction in claims will result.

MARKING REQUIREMENTS

Where a large quantity of freight is handled through a single warehouse, it is necessary to enforce rigidly the rules pertaining to the proper marking of less-than-carload shipments of freight. Not only is it necessary to require that packages be marked, but these marks should be affixed in such a manner as to prevent, so far as possible, their becoming detached or effaced. This rule should be especially enforced where the consignee is a private party or is not generally known in a business way, as with freight of this kind the name and destination are not sufficient but the street address also is positively necessary and should appear on both the package and the billing.

With certain commodities the location of the marking is important. This is particularly true in cases of eggs and crates of berries. Usually shipments of this character are handled in quantities and it becomes necessary to stack them in the freight house and car, so that marking on the end of the case is preferable to marking on the top.

The legibility of the marking of a shipment also is important, as a certain amount of handling by different men, both before and after a shipment reaches its destination, is absolutely necessary, and unless the marks are very distinct delivery is more than likely to be delayed. Where tags are used for marking they should be of a durable quality and securely attached, so that there will be little probability that they will be torn off in handling.

THROUGH CARS AND INTERLINE FREIGHT

When the volume of freight traffic reaches such proportions as to make the operation of through cars or through trains practicable for handling either local or interline freight, the operation of these through fast freight trains during the night, when the passenger service is off the line, has been found most satisfactory. Through freight for local delivery on any division is loaded in station order. When the quantity for one division is insufficient to require an entire car, freight for two or more divisions is loaded into it. Then it is moved to a junction point where the carload is split and transferred to the local express train on the division to which it is destined. These through fast freight trains may be made up of motor and trail cars, and this will enable the latter to be set out at the various division points to which they may be billed. This plan makes a morning delivery possible over quite a large system of lines, as the through train does not peddle the freight, except possibly over the division at the extreme end of the trip.

The development of interline business, when possible, in both carload and less-than-carload freight, provides a source of revenue which should be most profitable. It gives each railway company access to a territory for both freight originated and freight delivered which it could not otherwise reach. Interline freight business between two large terminals may be handled in a way similar to that already described, namely, a fast freight movement between distant points, which sets out cars at the various division points en route to be picked up the following morning by the local express trains operating over the division to which it is destined.

A recent decision of the Interstate Commerce Commission ordering through freight train service by the electric railway companies operating between Indianapolis, Ind., and Louisville, Ky., indicates that if interurban lines do not take advantage of the possibilities of an interline freight business on their own initiative, they will be forced to do so in case a demand comes from the shippers in the territory served. Quite a number of electric railway companies have seen the possibilities of this character of service and are doing everything in their power to

Freight Depot and Tracks at Los Angeles, Pacific Electric Railway—Receiving Shed at Left and Delivery Shed at Right

stimulate traffic from their own to foreign lines. The distribution of the electric railway map by the Central Electric Traffic Association has been a great factor in stimulating interline business. Many shippers were not aware of the existence of the various connecting routes throughout Indiana, Ohio and Michigan, information which the map sets forth quite plainly.

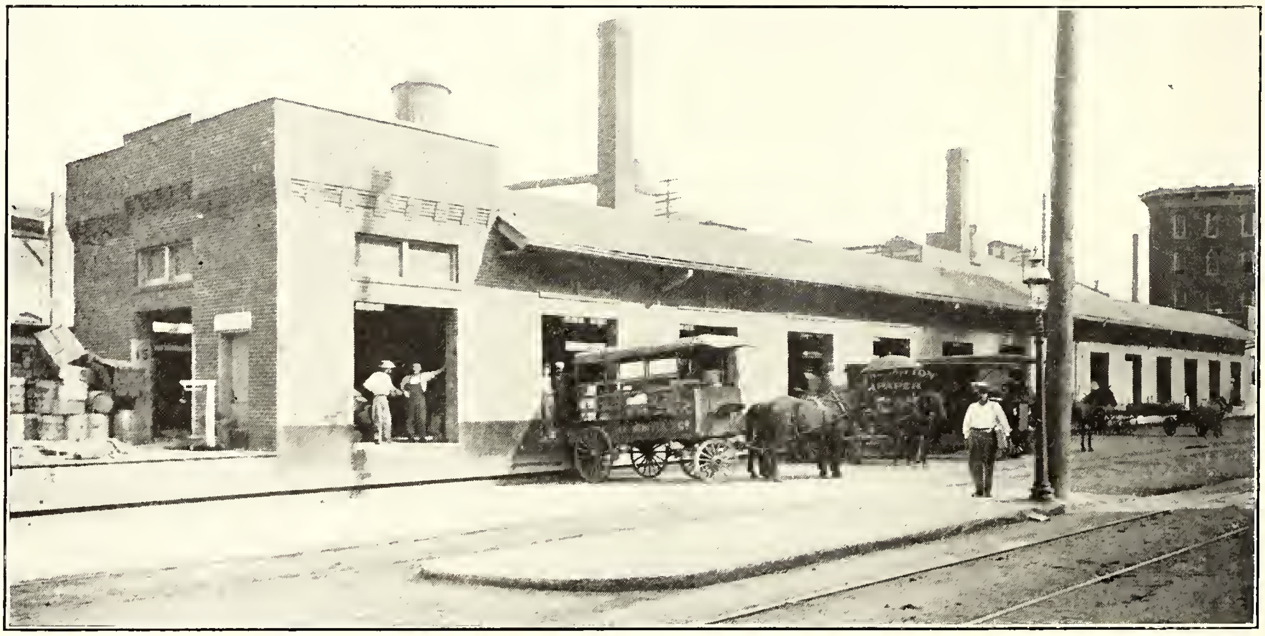
IN-BOUND FREIGHT METHODS

Modern tendencies in the handling of in-bound freight through terminal warehouses lead to a segregation of the in-bound and the out-bound traffic, either into two separate freight houses or by assigning a certain portion of the warehouse floor for in-bound freight. Under either of these arrangements, both in-bound and out-bound deliveries and receipts may be made without interruption. Where receipts and deliveries of freight are spread over the day—that is to say, where several trains are operated over the lines at different periods during the day—an in-bound and out-bound warehouse is a necessity, if any quantity of freight is handled. Where single express and freight train movements are made over the line out of a large terminal—that is to say, with all out-bound freight leaving the terminal at night and all in-bound freight arriving at the terminal in the morning—it is possible to utilize a warehouse for in-bound freight during the morning and out-bound freight during the afternoon.

The method of receiving and checking in-bound freight at the larger freight houses is much the same as that practised by steam roads. After all freight has been unloaded from the car it is checked with a blind tally sheet, a method which appears to be most satisfactory. When a check by this tally sheet has been completed by the unloading clerk it is compared with the way bill. If an over or short shipment occurs, a re-check of the car is made before the unloading clerk makes an O. S. & D. report. If the tally sheet checks with the way bill, the latter is turned in to the clerical force, where the rates are checked and expense bills prepared. Usually a postal card notification to each shipper is made out with each expense bill.

SYSTEM OF HANDLING OVERS, SHORTS AND DAMAGED SHIPMENTS

In case shipments are "over," it is necessary that agents give a full description, showing name of shipper and consignee, if possible, and all other marks appearing on the packages, also the character and the weight of the goods and any other information which will be of assistance in securing a revenue billing. Over-shipments are delivered to the consignee only on surrender of the original bill of lading or other proof of ownership. At the time such delivery is made the agent takes a receipt and collects a sufficient amount to cover the excess charges for the over-shipment.



Team Side of Dayton Freight House, Ohio Electric Railway

On packages checked short from the car it is the usual custom for the agent to secure all the information possible from the crew, and he also must make a careful re-check to assure himself that the shortage is not the result of carelessness.

Some roads employ a separate report form for damaged shipments in addition to the over, short and refused reports. As a general rule, the claim department desires to begin investigation on damaged shipments as promptly as possible, and the separate form enables them to pick out damaged shipment reports much more readily.

In addition to the filing of the regular report forms on over, short and damaged shipments, the use of a register for recording this information in the general freight agent's office has been found very valuable. Generally reports coming from a local agent receive an office number, and the register is made sufficiently large so that all the information contained on the report may be written on a single line across two pages. If necessary to refer to old records of over, short or damaged shipments, it may be done expeditiously by looking up the information contained in the register.

SETTLING CLAIMS

Two important factors enter into the settlement of claims, and each has done much toward reducing the work. First, the agent should exercise great care in determining the character of the damage at the time the shipment is received and should make a full report upon it; second, the amount of the claim should be limited on the form of bill of lading employed.

In years past considerable time was required by steam roads to settle a freight claim, with the result that many shippers were dissatisfied. Electric roads, however, have profited by this experience and have made every effort either to settle claims promptly or else to explain their reasons for refusal. After every effort has been exhausted to bring about a fair settlement through correspondence, following a thorough investigation of a legitimate claim, if the demands of the shipper appear to be unfair, he should be personally investigated. Usually this course produces additional incriminating evidence or convinces the investigator that some error has been made in previous reports about the matter.

The experience of several large companies indicates that not many claims are carried up for suit but that they are compromised or abandoned, especially when the company's claim department brings good evidence to show that the railway was not liable for the damage or loss. Claims which do reach the court, however, are usually those for damage or loss of grain in transit and damage to live stock shipments. Damage to grain may be the result of loss through heating or through defective cars which permit the grain to spill in transit.

From time to time claims arise under the class known as "concealed losses," such as shortage in closed cases. In most instances the legal department or claim department has been able to establish non-liability, as it is very difficult for the shipper to verify the count at the time the goods were placed in the case. The fact, too, that merchandise of this character is handled by draymen at the receiving and delivery points brings in two other parties and makes it practically impossible to determine who is responsible for the loss.

General practice in holding shipments in storage is to establish forty-eight hours' free time, after which they may be deposited in a public storehouse or carried to a central storage point owned by the railway company. In case the shipment consists of perishables, it is sold before it becomes unmarketable, and an accurate record of the transaction is kept for future reference. In case perishable shipments handled in this way are called for by the consignee at a later date and there are no freight charges to be deducted, the storage charges are subtracted, and the amount of money remaining is turned over to the consignee.

Some roads make it a point to dispose of hold-over shipments in storage at the end of six months, while others are compelled to hold them for one year. Following the sale of storage shipments, all expenses are deducted, and the amount of money remaining some companies add to their receipts, while others are compelled by law to deposit it in a charitable fund which is maintained and distributed by the state.

Interior of Dayton Freight House, Ohio Electric Railway

REQUIREMENTS FOR RECEIPT AND DELIVERY AT CROSSROADS

Quite a number of electric roads continue to make deliveries and receive freight at crossroads where agents are not maintained. The experience of some traffic managers in handling shipments of this character has been very unsatisfactory, and it has been abandoned. The general rule has been that a receipt given to the shipper at a crossroads or at a regular station requires that every shipment of this character must be prepaid and that the railway company is relieved of all liability after the shipment has been deposited on the platform at the destination. Although this method relieves the railway company of all liability, thefts resulting from this practice have made dissatisfied shippers and in many instances lost the company other freight business. When it is possible to operate the local express service on a regular schedule so that the consignee may know when to be at the stop to receive his consignment, deliveries at crossroads need not be discouraged.

DEMURRAGE AND SWITCHING CHARGES

A report from a large number of roads scattered over the United States indicates that most of them are operating according to steam road practice by charging demurrage on cars at the end of the forty-eight-hour free period. This rule usually is adhered to both as regards loads and empties, and its adoption was forced on a number of electric railways because shippers attempted to use cars loaded with coal, lumber and gravel as a warehouse until such time as they could unload them. No convincing argument can be advanced against its general adoption, as it adds to the revenue by increasing car mileage for a given number of cars in service.

Experience has shown that freight received or delivered to and from connecting lines in which the electric road participates in the revenue only to the extent of a switching charge is unprofitable but is one of the phases of the industry which a common carrier must meet. Exceptions to unprofitable switch movements are those where the road making the delivery participates in the revenue at a certain rate per ton with a minimum and maximum charge per car delivered.

FREIGHT EARNINGS AND DESIRABLE COMMODITIES

Roads not engaged in a general interchange of freight and limited to less-than-carload business use the standard electric railway express cars exclusively for this purpose. The quantity of freight handled in this way produces approximately from 10 to 12 per cent of the gross income. On roads engaged in a general freight business, with proper equipment to handle all classes and with interchange relations with steam roads, the proportion of revenue returned from freight traffic amounts to between 30 per cent and 50 per cent of the gross income.

Electric roads which are engaged in conducting a general freight business have found it necessary to make a careful study of the various kinds of merchandise handled with a view to taking exception to the official classification by refusing to handle certain commodities, or by specifying how they must be prepared before they will be accepted, or by applying a minimum, or by increasing the rate. It is also possible for freight agents to eliminate certain commodities, classing them as undesirable business and not soliciting them.

Under the heading of "desirable shipments" most electric lines place all classes of merchandise coming in closed cases, such as boots, shoes, dry goods, staple groceries, etc. Other desirable commodities include bulk or carload freight, but some companies are unable to handle shipments of this character owing to franchise restrictions. If an electric road will properly equip itself for handling bulk freight—that is to say, if it will install team tracks, grain elevators, etc.—it will find that such freight is not only an excellent revenue producer but is not subject to claims for damage or delay en route.

Adams Express Delivery at Allentown, Lehigh Valley Transit Company

ELECTRIC RAILWAY SIGNALING

EVER since the first single-track electric railway began operation the need for block signals in some form has been recognized. Even as early as 1891 the decidedly primitive arrangement of lights on a circuit extending between sidings, and controlled by a hand-operated switch alongside of the track was in use. About 1895 trolley contact signals began to appear, together with some contact devices for automatically operating the switches on the earlier light-circuit systems, although by the end of the decade most of the latter had dropped out of existence. Some intermittent control systems, including the trolley contact scheme, however, survived through the early stages of signal development, and in the year 1901 these were apparently conceded to be the only competitors of telephone train dispatching, the latter of course being the logical application of single-track steam railroad operating methods to the then light traffic of electric interurban railways.

However, neither telephonic dispatching nor intermittent control signals were considered at that time to have attained the perfection which had been developed in dispatching or block signaling on steam railroads, because the elaborate dispatching methods of the latter were made practicable by the presence of a telegraph operator at each meeting point—an utter impossibility for electric railways—and because the incomplete state of development of the early forms of intermittent control signals left much to be desired in their operation.

The track circuit which had come into extremely wide use for automatic block signaling and the control of manually operated signals and interlocking layouts on the steam railroads was at this time believed to be unsuitable for electric railway use owing to the necessity for utilizing the rails for a return circuit and thus preventing the separation of the track into a series of sections or blocks by means of insulated joints.

On the Boston elevated lines a system of track-circuit signals was placed in operation in the year 1901, but in this installation the problems were simplified by the existence of the steel supporting structure to which but one of the rails was grounded, so that the other rail was free to be divided into as many insulated sections as were required. In consequence, d.c. apparatus such as had become largely standardized upon steam railroads could be used, the operation of the signals being effected by low-voltage currents which were shunted away from the signal-operating relays whenever the presence of a pair of wheels provided a short-circuit path across from one rail to the other. This single-rail system was, however, hardly available for ordinary electric railways with earth or stone ballast where the rails, owing to the possibility of defective bonds, had to be cross-bonded at short intervals and where the distances covered were so great that both rails were needed for propulsion current return.

In fact, during this period considerable written comment was made regarding the lack of a thoroughly satisfactory signal system for electric railways, the Massachusetts Street Railway Association, through a number of queries sent out to various street railways, finding the prevalent idea to be that while signals were required for single-track operation, the systems then in operation

Home Signals for Adjoining Blocks on New High-Speed Line to Trenton, Public Service Railway

were not reliable. The principal defect in existing signals appeared to be a lack of ability to indicate the presence of more than one car in a block at one time, so that in following movements the rear car of a train run in sections was protected only up to the time when the first car left the block. It is obvious that in the majority of replies to this inquiry only trolley contact signals were considered, but it is interesting to note that the principal objection to them was not the danger of a failure in the operation of the trolley contact device on account of the car passing it while the trolley or the power was off but was rather the lack of the car-counting device which later was developed to register cars in and out of the block and thus to allow permissive following movements. No very serious consideration seemed to be given to rear-end protection at this time, and but few double-track roads were believed to require signals.

Two years later, however, the track-circuit signal suddenly became available for use on electric railways through the commercial development of a.c. signal apparatus as installed on the North Shore Railroad in California, now a part of the Northwestern Pacific Railroad, and within a negligible period of time the track-circuit system changed its position from that of an utter impossibility to one which was strongly reinforced by the years of experience gained through actual operation on steam railroads.

The differences in principle of operation between the a.c. and the d.c. track circuits were of course negligible and the actual changes in apparatus were comparatively few, although they added materially to the cost of installation. The major change consisted in the use of "impedance bonds" which were installed to replace the customary cross bonds and which were located at the ends of each insulated track section or block, taking the form of coils with a highly inductive effect to prevent the passage of practically all of the alternating signal current. The coils installed at the adjoining ends of blocks were, however, connected at their centers and the connection served as a return path for the direct propulsion current.

The development in methods and thoroughness of protection for double-track roads by a.c. track-circuit signal systems has naturally been rapid since the first installations, but during the same period an equally great improvement has been made in the operating features of the various intermittent control types, consisting in the previously mentioned car-counting devices, contactors with a directional sense, indicators to prove the operation of the contactor, and the closed circuit systems which guard against false clear indications. In addition, a number of dispatcher's control systems have been developed through which the dispatcher is enabled to direct the movement of trains by telephone orders and semaphores or other arrestive devices operated from his office.

During the last ten years therefore the conditions confronting electric railways in the matter of signal protection have been completely reversed. To-day a number of manufacturers have placed upon the market apparatus of demonstrated ability, and the problem of signal installation is no longer one of engineering but rather one of first cost. It is somewhat surprising therefore that interest in the matter has lain largely dormant for the greater part of this period. Indeed, it is only within

View on Northwestern Pacific Railroad, the First Line to Be Equipped with A. C. Signals, Showing Home and Distant Blades on One Mast Because of Short Block in Advance

the last three years that sufficient attention has been devoted to block signaling for electric railways to cause it to be taken up by a special committee of the American Electric Railway Association. The formation of this committee has, however, stimulated interest to a marked degree, and this has been considerably augmented by the recent installation of signals over a comparatively large mileage of track on the interurban railways of the Middle West. In some respects, therefore, the subject of signals presents more features of novelty than any other which concerns the electric railway industry at the present time, for but a small proportion of the total electric railway mileage in the country is protected to the extent desired by operating officials.

COMMERCIAL TYPES

Generally speaking, the commercial forms of electric railway signals may be separated into three distinct classes, namely, dispatcher's systems, intermittent contact types and those with continuous track-circuit control.

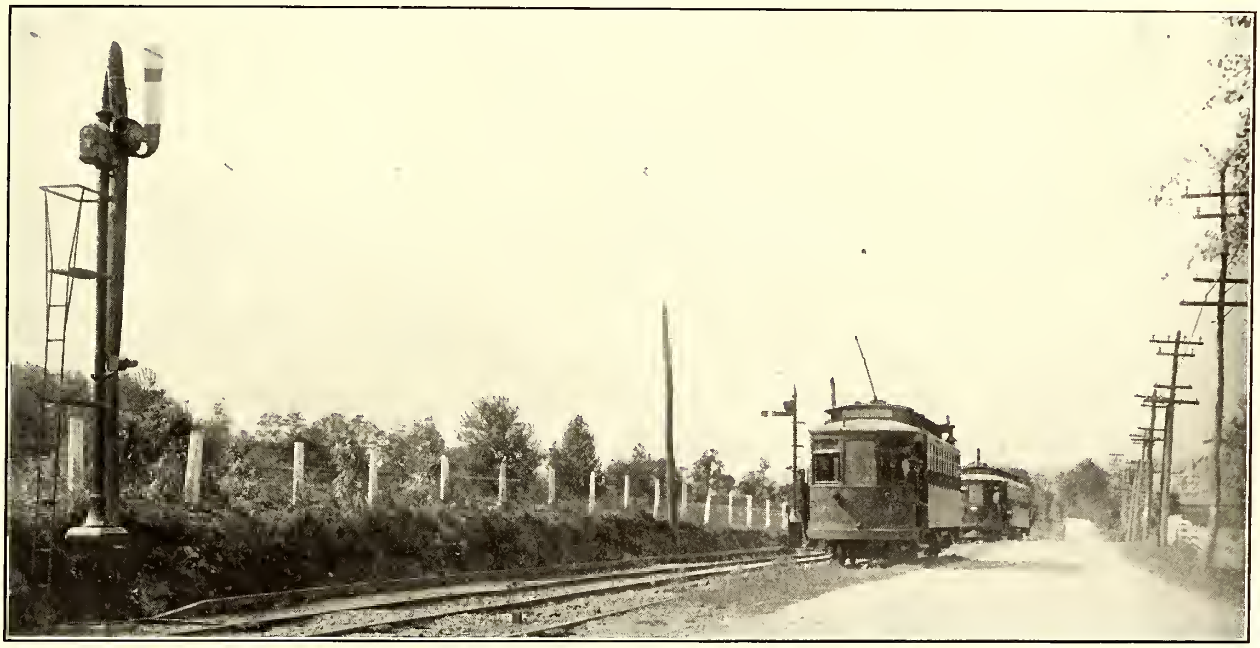
The dispatcher's systems of signaling which are in general use to-day are not directly included in the scope of this article, although a brief mention of them is warranted by the very considerable mileage which they serve. The important characteristics include an electric selective device which is operated by synchronous impulses sent over a single wire from the dispatcher's office and which sets a semaphore or other arrestive device at some point along the line where it is desired to stop a train for orders. The desired orders are given by the dispatcher to the train crew by a telephone mounted either on the signal mast or else within the car and connected at stops with a telephone receptacle on the mast by means of a flexible cord from the car. The arrestive device is usually cleared by the train crew after orders have been received.

About three years ago the Indianapolis & Cincinnati Traction Company made an installation of Simmen signals—a semi-automatic system which constitutes a radical departure from the generally accepted method of train protection. This system is by no means comparable with any of the types heretofore placed upon a commercial basis, but since it centralizes control of train movement in the hands of a single dispatcher it may be classed most nearly as a form of dispatcher's signals. It does, however, plan to eliminate the element of human fallibility by mechanical means, as it reduces the duties of the dispatcher to a series of operations of the simplest character and provides an automatically printed record to show the movements and position of all trains along the line.

In brief, this system consists in placing at each siding three insulated sections of third-rail about 75 ft. long and spaced at intervals of about 2000 ft. Each group of three sections is connected to a dispatcher's office at any desired point along the line, the wire from each group being connected to a separate control switch mounted on the dispatcher's switchboard. There is, therefore, a control switch which corresponds to each siding. Each car is equipped with a third-rail shoe, and whenever this is passing over any of the third-rail sections it is thus possible to complete a grounded circuit through any desired form of apparatus on the car.

In consequence the dispatcher can set the control switch for any siding so that the voltage from a battery is impressed upon the group of third-rail sections at the siding, and as soon as a car passes any one of the three sections the current, in flowing through the circuit between the third-rail shoe and the wheels on the car, closes a relay on the car and lights a green lamp in the cab.

A shunt circuit on the car keeps the green lamp burning until the relay is again de-energized by the breaking



Upper Left-Hand Quadrant Signals Located on Same Side of Track, Lehigh Valley Transit Company—Waiting Car Held by Stop Signal Until Opposing Car Enters Siding

of the local circuit due to the lifting of the third-rail shoe in passing over the next section of third-rail. If the latter section is not energized by having the dispatcher's switch in the proper position, the relay armature on the car is allowed to fall and thus closes through a back contact a secondary local circuit which connects the battery to a red light and which naturally stays closed until the relay is once more energized by passing over an energized third-rail.

The dispatcher's control switches, one for each siding, are set in a row at the edge of a table, and the handles stand vertically but have a movement to the right or left of 45 deg. With a handle in the vertical position the corresponding circuit is open, but when the handle is moved either to the right or the left the circuit is closed and the third-rail sections are energized. In practice the dispatcher sits with his back to the track, and when he wishes to clear any siding for a car moving toward his left hand, he moves the proper handle to the left. The handles are, however, mechanically interlocked, and it is impossible to set the pair of adjoining handles so that the left-handed one points to the right and vice versa. If one handle is moved to the right, say, and thus gives a clear indication to the train at the corresponding siding, the next handle to the right must be kept vertical, holding any train which may be at the adjoining siding. In this way trains at adjoining sidings cannot both receive clear signals to approach each other and thus meet head-on between sidings. In addition, the handles in the latest form of this signal are electrically interlocked so that when once a train is in a block it becomes impossible to change the position of the control handle and thus open a way to let an opposing train into the other end of the block. Opposing movements of trains at a meeting point are controlled by the two outer third-rail sections of the group at the siding, and two trains which approach the same siding receive danger signals as soon as they pass these sections, leaving each train some 2000 ft. in which to make a stop.

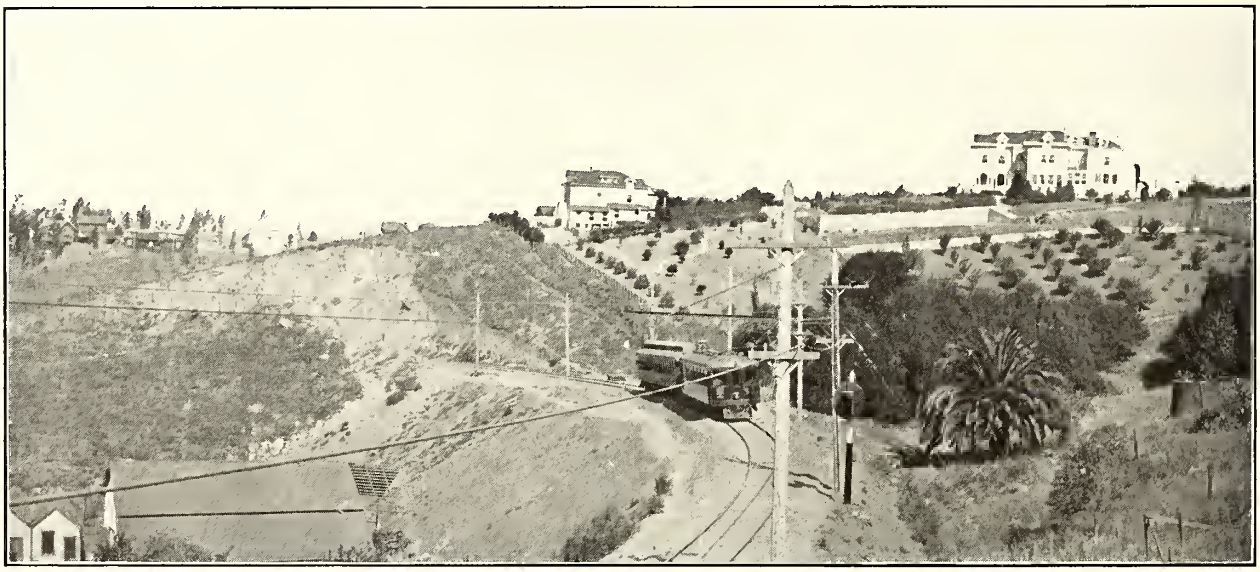
The circuit which is completed when a car stands over one of the third-rail sections, in addition to its control of the lights in the cab, is utilized for telephonic communication direct from the cab to the dispatcher, and a motorman can receive his orders without leaving the car.

This system is more costly, although it is much less complex in the details of apparatus than the ordinary dispatcher's telephone systems. It is, however, less costly than track-circuit signals designed to give the same train spacing when absolute blocking is carried out for following movements, and of course when permissive following movements are allowed the spacing of trains in the same direction may be very much reduced. The cost of installation for a 50-mile line with sidings 5 miles apart approximates $800 per mile.

INTERMITTENT CONTROL SIGNALS

Special interest attaches to the group of signal systems which may be classified as the intermittent control types, among which only the trolley contact signals are now prominent; for, as previously mentioned, these were developed solely to meet the peculiar requirements of the early electric railways. While this class of signals retained complete supremacy in the field, so far as automatic devices were concerned, only until 1903, they are to-day in a most enviable position in their ability to furnish signal protection at an exceedingly moderate cost. This feature is, of course, one of serious moment to the average interurban or city railway which has to obtain the major part of its revenue by hauling passengers at rates of from 1 cent to 2 cents a mile, or at a figure under which a steam railroad would actually lose money.

All of this general class of signals have developed certain standard characteristics, and they differ from each other only in details of design or in methods of arriving at the same result, which is to provide, by mechanical means, absolute head-on protection and either absolute or permissive blocking for following movements within a series of self-contained blocks. Each block is equipped



Light Signals Near Berkeley, Cal., Oakland, Antioch & Eastern Railway

with two main signals, one at each end, each having a contactor located near it, and both signals are electrically connected or interlocked so that the operation of one involves the operation of the other, often through a single circuit of low first cost. Each signal is arranged so that whenever its contactor is passed by a car moving into the block the signal movement will actuate some form of ratchet or other counting device in a certain direction.

Any movement of a car past the first contactor in the opposite direction, or else out of the other end of the block past the other contactor, actuates the ratchet in the same manner but in the reverse direction, so that whenever a car enters the block it is automatically "counted in" and when it leaves it is "counted out." Both signals are prevented from clearing up until the ratchet has finally reached normal position, or, in other words, until as many cars have moved out of the block in either direction as have entered it. Light signals in combination with disks or arms are generally used, power being obtained from the trolley. Indications are, however, usually locked mechanically so that a temporary interruption of the power supply will not derange their operation.

Trolley-Contact Signal for Interurban Service in South Bend, Ind.

Making Repairs to Trolley-Contact Signal in the Field

Trolley-Contact Signal on Line of Nashville Interurban Railway.

Differentiation between cars which enter the block and those which leave it obviously requires a contactor with a sense of direction. This is variously obtained, one method consisting in the use of a pendulum which is struck by the trolley wheel and is thus moved in the same direction as that of the car until it closes one of two circuits provided at the contactor. Another method involves two quick-acting interdependent relays which close different circuits according to the relay which is first energized.

The electrical connection between the two signals naturally permits the display of a different signal indication for following and for opposing movements, and it is customary for the signal which is passed when a car enters a block to be set at caution, allowing following cars to enter the block under control. The signal at the opposite end of the block is set at stop by the same movement and thus provides absolute head-on protection for the full block length. Protection against simultaneous entrance of the block by opposing cars is obtained by making one of each pair of signals slow-acting, by producing a special indication or lack of indication and the like.

Permissive following movements are, however, by no means an essential feature of intermittent control signals. The signal passed by a car when it enters the block may, if desired, be made to display a stop indication and thus prevent any following car from entering the block until the first one has left it. Such a method of absolute blocking is in use on a number of roads, and where traffic conditions permit it is unquestionably a desirable plan of operation.

The adoption of absolute blocking for following movements with intermittent control nevertheless does not in general eliminate the necessity for the car-counting device, which might appear to be valuable only under the permissive system. Even under the most rigidly enforced operating rules there is always the possibility for violation of them either by carelessness or because of an emergency. When this occurs a car following another into the block is left without protection as soon as the first car leaves the block unless the car counter is installed to hold the signals at danger, and for this reason the counting device is considered desirable regardless of the method used for blocking following movement.

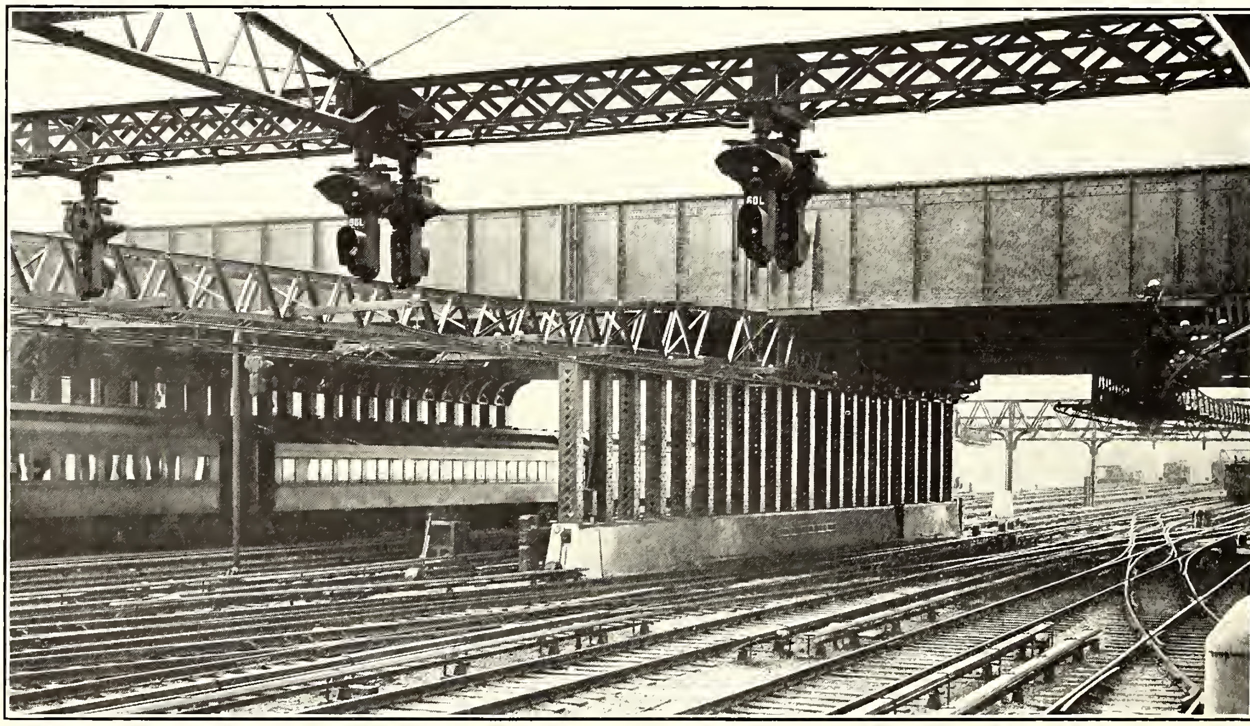
There is, however, an objection to the use of intermittent control for high-speed service which lies in the fact that a failure to operate may leave a signal at clear. This is covered in most cases by setting the signal in advance of the contactor so that the motorman approaching it can see by the change in aspect that the contactor has operated. To this plan, however, exists the objection that motormen may be required to run by stop signals in case absolute blocking against following movements is practised because a stop indication is then given at the entering end of the block as soon as a car passes the contactor. A recent plan for overcoming this is to provide an indication for the operation of the contactor in the form of a special signal some distance in advance of the entrance of the block. This would, of course, properly cover the operation of the signals at both ends of the block, as the mutual operation of the two can be guaranteed by wiring them so that a short-circuit, ground or failure of power will produce stop indications. Failures of the car-counting device may also be provided against in a similar manner.

These "check indications" are perfectly satisfactory for movements at moderate speed and in locations where signals are not too frequent, but where signals have to be passed at high speed and at short intervals the additional duty imposed upon the motorman through the necessity for ascertaining that each signal has operated, thus distracting his attention from the track ahead, is generally considered to be a drawback. In brief, it may be said that the track-circuit signal system is the only one now in existence which is absolutely certain in operation and which in consequence does not need to have its operation checked. This is accomplished, however, only at a comparatively great expense, and if a less expensive form of signal is used, a greater degree of discipline for the motormen must be enforced to make up for it. With this exception the most improved forms of trolley contact systems leave nothing to be desired on the score of protection, nor do the latest forms of trolley contactor appear to limit the speed at which they may be safely passed.

On the other hand, for slow-speed service the latest developments in this type of block signals render it ideal not only because the first cost is exceedingly low but because no need exists for digging up the track, when the signals are installed, in order to rebond rails, insulate the sectionalizing joints and remove tie rods as is required with track circuits. The cost of a block 1 mile in length may be said roughly to approximate $550, of which $400 covers the cost and erection of the two signals and the two contactors. The remaining $150 covers the cost and erection of, say, four line wires, a figure which would, of course, vary directly with the length of the block in case any length other than 1 mile was used.

SPECIAL FORMS OF INTERMITTENT CONTROL SIGNALS

Four forms of intermittent control signals are in a practical stage of commercial development at the present time and all of them are operated by trolley contact devices.



Light Signals with Two Indications, Pennsylvania Railroad Terminal in New York City

Of these four types, the Nachod signal is furnished with a trolley contactor which has no moving parts, and which consists of a pair of metal strips on each side of the wire, so that the trolley wheel, in passing it, bridges across between the strips and trolley, closing the operating circuit. A pair of quick-acting interconnected relays is used to give the directional sense, the first one to operate holding the other open during the passage of the car. These relays, being slow releasing, are not affected should the trolley wheel bounce after it strikes the contactor. In a recent test on the lines of the Northern Electric Light & Traction Company signals were operated successfully by these contactors when cars were operated at speeds of over 75 m.p.h.

With this signal the indication is given both by a colored light and by an opaque disk of the same color viewed through a clear glass roundel. The effect of bright sunlight or a dark day is to dim the one and increase the brilliance of the other, so that there is always a distinct indication for any lighting. Opposing movements are prevented by a red light and a red disk, and following movements are allowed by a white light and a white disk, permissive movements past a white signal producing a "blink" in the light as an indication that the car has registered into the block. Simultaneous entrance of cars at opposite ends of the block leaves the signal at "neutral," or gives no indication. As cars are required to obtain white indications before entering a block, in case the light does not appear both cars must back out past the contactors and try to enter the block a second time, the first one in obtaining a white signal and setting a red against the other. One form of this signal uses but one line wire, the operating circuit being completed through ground. This is designed for use with double-end sidings with spring switches where cars invariably pass to the right. In this case contactors without directional sense may be used if one is set over each track at the siding.

Another form with the directional feature has an additional line wire, required for the rare occurrence of a car running into the block against a red signal and having to back out again. The extra wire enables the car to count in on the signal relay for following movements at the opposite end of the block. Thus the car counts out as it backs out of the block without pulling down trolley under contactor, the signals being left in exactly the same condition as before its entrance. This type protects all possible shifting movements. In case absolute prevention of false clear indications is desired, a third form of this signal is furnished. In this, by means of four line wires, the signals are held in clear position by power and they fall to stop position by gravity in case of any derangement of the wiring, the signals at each end of the block being electrically interlocked so that a car cannot enter a block until the signal at the opposite end has actually moved to stop.

In another form of the trolley contact system—the Chapman signal—the indications are given by a pivoted arm painted red which assumes different positions in front of a white disk or background. The arm is illuminated at night by a bank of lamps carried in a hood which extends out over the front of the signal and which serves to reflect the light against the arm and to make it stand out prominently against its white background.

The signal indications consist of a horizontal position of the arm as a stop sign for opposing movements, a vertical position of the arm as a permissive following movement indication and a 45-deg. position as a normal or neutral indication. The latter position is assumed by the signals at the two ends of a block when the block is clear. When a car enters the block the arm on the signal at the far end of the block first moves to the horizontal position and is locked, then the arm at the entering end moves to vertical. In other words, the permissive indication at the entering end cannot be obtained until the stop at the far end is set. This is of extreme importance since, in this way, a ground on the line wire gives a stop indication. The indication to show operation of the car-counting device is a momentary movement of the arm from vertical to 45 deg. followed by a return to vertical position.

The trolley contactor is of the pendulum type, a tongue pivotally supported in the path of the trolley wheel closing one of two circuits corresponding to the direction in which the car is moving. When one con-

View on Terre Haute, Indianapolis & Eastern, Showing Light Signals for Adjoining Blocks Mounted on One Mast

tactor acts, the contactor at the other end is automatically cut out, and simultaneous operation when two cars reach opposite ends of the block at the same instant is avoided by making one contactor slow-acting. All power is obtained from the trolley feeders. Only two line wires are used.

A contactor of the pendulum type is also used for the United States Electric Signal Company's signals. In the car-counting type the contactor operates to set the signals to display a single red light and below it a red disk behind plain glass for opposing movements and a white light in combination with a rotating disk for following movements. A non-counting type of signal is also manufactured.

On either side of the signal case an inclosed white semaphore disk with green center is provided, which in its normal position presents only its edge to view but when operated to display its indication is rotated on a horizontal axis to present its flat surface to view and is simultaneously illuminated by an incandescent lamp contained in the semaphore case.

Light Signal with Permissive Indication, Union Traction Company of Indiana

The permissive indication for a car entering an unoccupied block is by the display of one of the white disks. The permissive indication for following movements is a shifting of the indication from one side to the other for each car entering the block. Interlocking control of the signals, one at each end of the block, is obtained by circuits operating through two line wires.

The Ward signal, which was placed in operation some two years ago, has a novel contactor which is operated by the raising of the trolley wire which occurs as the trolley wheel passes along it. The contactor proper is contained in a box carried on one of the span wires with the actuating rod extending out of the bottom and attached to the trolley wire with a standard ear. Standard three-position semaphore arms in combination with lights for night operation are used as indications, permissive following movements under caution signals being provided for, if desired, by means of an interlocking car-counting device. The contactor is reported to permit operation at the highest speeds as it involves the use of no obstruction on the trolley wire. The company also furnishes directional contactors of another type which are likewise adjusted for high speed. Three wires are used in the control circuits. Failures on account of the trolley pole having insufficient tension to lift the trolley wire and actuate the contactor or when the wire is heavily loaded with sleet are reported to be an impossibility. In any event, however, the assurance of operation is given by the usual procedure of setting the signal some distance in advance of the contactor so that the motorman can see the signal change indications.

CONTINUOUS TRACK-CIRCUIT SIGNALING

As previously mentioned, the continuous track circuit became generally available for electric railways through the introduction of a.c. signal apparatus in 1903. At that time the first cost of a.c. track-circuit systems was considerably greater than that of the d.c. systems which could be used upon steam railroads, and this proved to be a serious handicap to the track-circuit system except upon electric railways with exceptionally dense traffic. In consequence they were first used only to meet special local situations or upon lines whose density of traffic had warranted the installation of double track. The situation was, in fact, quite similar to that which existed in the steam railroad field until a short time ago, the consensus of opinion being that traffic which did not require double tracks would not successfully support the cost of a complete track-circuit installation.

Naturally, under these circumstances the developments in continuous track-circuit signaling were largely applicable to double-track operation just as they had been in the case of the steam roads, and the vastly greater problems of single-track protection received but scant consideration. Thus two of the first a.c. track-circuit systems were installed on the double-track lines of the North Shore Railroad in California and of the New York Subway. The installation on the former railway was a good example of the attitude of the period, for signals were installed only on that part of the line which was double-tracked, leaving the single-track branches to be operated by telegraphic orders from a dispatcher. Both of these early signal installations, it should be said, were operated on a single return rail system somewhat similar to that used on the Boston Elevated Railway except that alternating current was used for the track circuits. Neither system in consequence made use of impedance bonds, and it was, in fact, not until 1905 that this necessary device was introduced commercially, although here again the installation was on a double-track line of the Boston Elevated Railway.

The next three years saw a really remarkable increase in track-circuit signaling, as a large number of a.c. signals were installed, and even in the early installations the ability of the a.c. signal apparatus always to select the current for which it was designed was demonstrated. In the signal system installed on the New York, New Haven & Hartford Railroad's electrified division in 1907 twenty-five-cycle propulsion current was used, but the signal apparatus was designed for sixty-cycle current and the track relays successfully proved their ability to differentiate between the two frequencies impressed upon them.

Prominent among the early a.c. systems were the light signal installations of the Hudson & Manhattan Railroad and on the New York Central & Hudson River Railroad at its electrified terminal in New York City, which served in part as forerunners of the recently adopted plan of using light signals in the open sunlight.

LIGHT SIGNALS

This form of indication, consisting of a pair of red and green lamps mounted in a deep hood upon a signal mast beside the track, has been adopted by several interurban roads within the past two years. In operation the circuit for the green lamp is held closed by the relay connected across the two rails of the track just as a semaphore is held at clear. When the track relay is de-energized by the presence of a train on the same section of track as the relay, the green light circuit is broken and the red is lighted through a back contact connection on the relay armature.

The obvious advantages are mechanical simplicity and also, by the elimination of the semaphore operating mechanism, which requires a certain amount of inspection and repairs, a certain reduction in the cost of installation, although all equipment except the indication itself is exactly the same as with semaphores. This saving varies, under different circumstances, through wide limits, the estimates ranging from 5 per cent to 15 per cent. As opposed to this, however, there is an increased cost of operation due to power consumed in lighting the lamps, and a certain amount is involved in lamp renewals, so that the saving due to decreased first cost is by no means clear gain. In some of the latest installations, however, the expense due to lighting current and

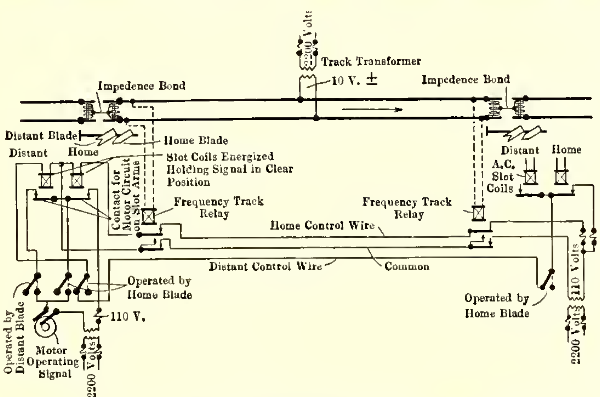
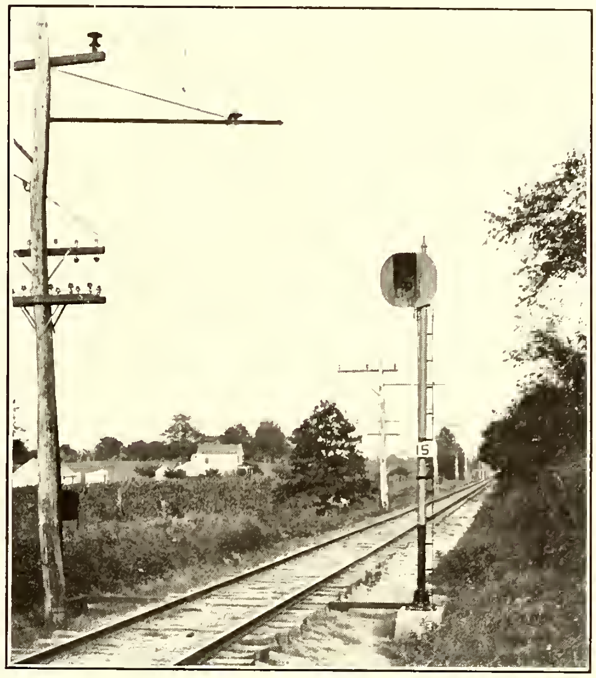


Fig. 1—Typical Wiring Diagram for Double-Track Two-Position Signals

deterioration of lamps is materially reduced by having the lamps lighted only when the signals are being approached by a train. To accomplish this the separate lighting circuits for lamps are closed only through back contacts on the track relays at each end of center-fed track sections. When a train is near the signal at the end of a block and consequently de-energizes the track relay, the armature in falling open closes the lighting circuit and supplies current to the lights. When no train is near the signals the track relays are, of course,



Advance-Intermediate Signal, Washington, Baltimore & Annapolis Railroad

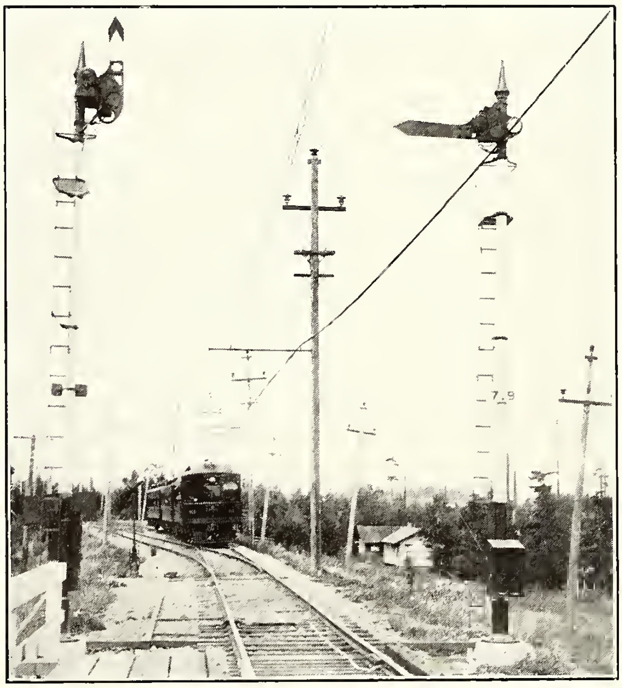
closed, and the lighting circuit is opened at the back contact of the track relay.

DOUBLE-TRACK SIGNALING

Until recent years practically all of the electric railway signal systems with track circuits were, as mentioned before, of the simple form which was required only to protect against following movements. Two-position semaphore signals were generally used, these being located at the entrance end of each block. The most modern development of this method will be found in the signal installation of the New York, Westchester & Boston Railway, of which a description was given in the Electric Railway Journal for July 20, 1912.

The accompanying cut, showing a typical track circuit, is reproduced from this descriptive article to explain the method of operation in a conventional form, the main principles applying to all forms of track-circuit signaling. This installation, it should be noted, makes use of center-fed blocks, a practice which involves the slightly greater complication of using two relays to each block instead of one, the object being to obtain a saving in power consumption and a somewhat more positive action of the relays. The absence will be noted of overlapping blocks to provide for a positive spacing between trains at all times and to provide a possibility for the use of automatic stops. This omission, which is in some respects contrary to the most recent trend of opinion regarding the elimination of the human element, is due to reasons which are outlined in the descriptive article, but in other respects the circuits are representative of the latest developments in double-track signaling, the endeavor being to attain the greatest degree of simplicity consistent with an absolute certainty that false clear indications cannot be given.

It will be observed from the diagrammatic signals shown in the illustration that the semaphores are operated in the lower right-hand quadrant. This is also contrary to the present trend of opinion, the reason for the use of this quadrant being that the signals on this line were designed to agree in aspect with those of the New York, New Haven & Hartford Railroad on account of the joint use of tracks. This question of signal aspects is, however, subject to certain differences of opinion at the present time.



Proceed and Stop Indications with Three-Position Signals, Oregon Electric Railway

SIGNAL INDICATIONS

The use of one of the left-hand quadrants is, of course, practically obligatory for electric railways because with any overhead contact system for propulsion current a perfect wall of poles has to be set up on at least one side of the track. With a semaphore arm operating in either the upper or lower right-hand quadrant, or, in other words, in some position to the right of the signal mast, the indication will be thrown toward the outside of the track and a motorman approaching a signal may have his view of it obscured by the intervening poles, or at least will have as a background for the indication the line of poles extending beyond the signal. With three-position signals confusion also may arise through the fact that the vertical or clear position for the semaphore arm will coincide with the vertical lines impressed upon the eye by the view of the poles ahead of the car.

For this reason the committee on block signals of the American Electric Railway Association has recommended for three-position signals the adoption of the upper left-hand quadrant indication, contrary to the practice of the steam railroads, upon which the upper right-hand quadrant has been generally advocated as a standard. For three-position signals the use of an upper quadrant is necessitated by the fact that a vertical downward position for the semaphore would be practically obscured by the signal mast.

The important differences in opinion, therefore, lie between two-position and three-position semaphores. With the latter all three indications which have become well standardized—namely, stop, caution and proceed—are given by one semaphore arm, so that to take advantage of the simplicity and economy of the three-position indication it is necessary to limit the length of block, or, in other words, to separate the home signals by a distance not greater than that which should properly be placed between a distant signal and its home signal. As the latter distance should be slightly more than the maximum distance within which the fastest train may be stopped by normal service applications of the air brakes, it may be on electric railways not more than 1200 ft., and any length of block even approximately as short as this is not often required or even desired on interurban lines. On the other hand, the adoption of the three positions as standard does not by any means prevent the use of separate distant signals indicating in but two of the three standard positions and thus following the standard aspects without giving up the principle of two-position signals where they are desired. The use of the vertical or clear position for the arm affords, of course, an opportunity for confusion owing to the lack of distinctiveness of the indication, but this is met by the advocates of the three positions with the argument that, so long as the signal furnishes a sufficiently arrestive indication for caution and stop, it has done the major part of its duty, as the distinctiveness of the clear signal can assist only in accelerating train movement.

The plan of having the separate and distinct daylight indication of a semaphore arm set at an angle of 45 deg. instead of giving the indication by means of two arms, the upper one horizontal and the lower one at an angle, is, in addition, a logical system on account of the standardization of three distinct night indications, consisting of a red light for stop, yellow for caution and green for clear. In addition, the modifications of stop signals which are now favored under special conditions, such as a semaphore below the main indication acting as a permissive or diverging route signal, are in this way devoid of much of the complication of aspect required when two-position distant and home signals are mounted on the same mast.

SINGLE-TRACK SIGNALING

The development of single-track signaling with track circuits may be said to have begun only within the past five years. One of the reasons for this has been, as mentioned before, the lack of demand on account of the relatively great expense of such systems for single-track railways whose traffic was necessarily only moderate in density. Such systems involve a first cost ranging from $1,000 to $2,000 per mile, depending upon the block length and the facilities employed for the acceleration of traffic. Until quite recently, therefore, the continuous track circuit for single-track lines was used mainly for special circumstances such as short blocks of single track and for the protection of curves where the view was obstructed by a deep cut or a grove of trees.

Such a signaling problem is, of course, exceedingly simple. A single signal at each end of the curve or section to be protected is installed alongside of the track so that each signal faces the traffic approaching the curve

The above-described block for simple curve protection displays the characteristics upon which the earlier developments in single-track signaling were based. The so-called preliminaries have been, in fact, a feature of practically every single-track installation until less than two years ago, notwithstanding the fact that their use affords an opportunity for a train approaching the siding at the end of one block to stop an opposing train at the next signal, which is possibly one full block away even though the two trains are scheduled for a meet at the siding. Thus,

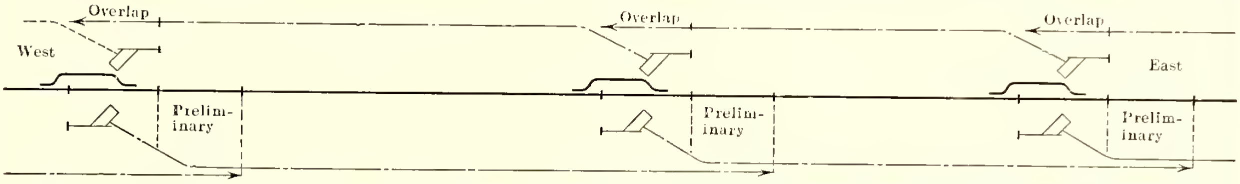


Fig. 2—Diagrammatic Arrangement of Signals for Simple Single-Track Blocks with Overlaps and Preliminaries

and will be seen at the right-hand side of the track by such traffic. If the section of protected track is insulated and equipped with reactance bonds at the ends, fed with alternating current at low voltage, and is furnished with a track relay at each signal to hold closed the operating circuits of the signals, it is obvious that a car on the curve or block as it would then become will set both signals at stop position regardless of the direction of motion.

THE USE OF PRELIMINARIES

This as it stands would be sufficient except for the fact that there is a possibility of two cars entering the block from opposite ends at the same time or at least sufficiently near to the same time to let both motormen past the signals without noticing that they were set at danger. This possibility may be eliminated by extending the control of one signal from 1000 ft. to 2000 ft. beyond the signal at the opposite end of the block. This "preliminary," or extension of the track circuit outside of the limits of the block as defined by the track between the two opposing signals, will then enable a car which passes

if an east-bound train was somewhat late for a meet at a certain siding and did not get into the next block to the west of the siding before the west-bound train had entered the preliminary which is assumed to extend to the east of the meeting point, the east-bound train would obviously be held at the home signal controlled by the preliminary until the west-bound train had moved into the clear on the siding. This might involve a considerable lapse of time and cause additional delay to the train already late; yet it would not result from any necessity for protection, because the west-bound train within the preliminary would be protected by the east-bound home signal at the siding against any possibility of being hit by the east-bound train. In brief, the preliminary is a limitation imposed solely to provide against the rare occurrence of two opposing cars entering the block simultaneously.

SINGLE-TRACK BLOCKING WITH PRELIMINARIES

A typical example of simple single-track blocking with preliminaries is shown in Fig. 3, which presents diagrammatically the scheme installed upon the lines of the

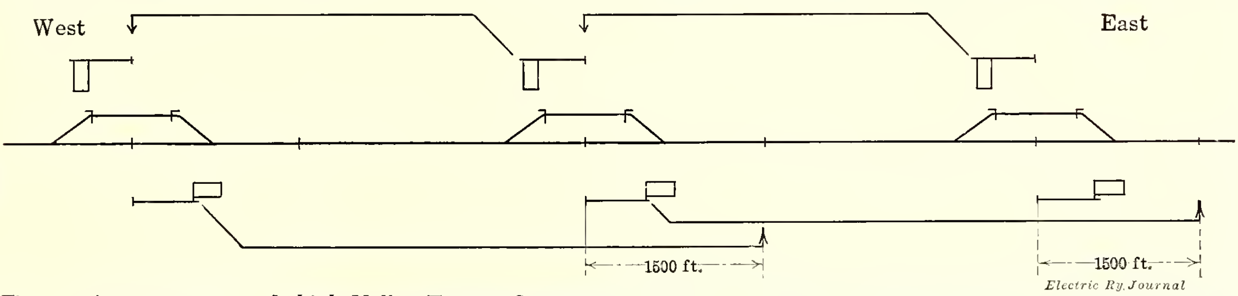


Fig. 3—Arrangement on Lehigh Valley Transit Company Having Normal Stop West-Bound Signals and Normal Clear East-Bound Signals with Preliminaries

on to it to set the signal at the opposite end of the block some time before the nearer signal is passed. If another car should enter the opposite end of the block at the same time that the first car entered the preliminary, the first car would receive a stop indication from the nearer signal when at an ample stopping distance from it. The preliminary section under the circumstances would be insulated from the block and would require a track relay connected to it to make or break the operating circuit of the signal at the opposite end of the block.

Lehigh Valley Transit Company. In this installation, one of the latest plans of the General Railway Signal Company, the signals governing west-bound trains stand normally at stop, while the east-bound signals are normal-clear. The preliminary is used in every case as a clearing section for the normal-stop signal, and when a train enters this section of track the circuit of the motor for the signal which is being approached by a west-bound train is closed and causes the signal to indicate proceed. If there is a train already within the block, however, the motor circuit is kept open and the signal remains at stop, preventing the west-bound train on the preliminary section from entering the block. This combination of normal-clear and normal-stop signals affords a means for electrically interlocking opposing signals so that one of the signals must indicate stop before the other can indicate clear.

Absolute blocking for following movements is employed and trains are required to head in and back out of all passing sidings, so that a train on a siding after the passage of an opposing train has its rear protected by the signal one black away at its rear and can start into the next block under full protection provided the signal which it faces is at clear when the car backs out of the switch. The track in each siding which extends beyond the clearing points is not included in the track circuits, so that a train in the clear on a siding cannot interfere with the movements of approaching trains.

This is the simplest and the least expensive of the most recent developments made by the manufacturer mentioned, although light signals would have been somewhat cheaper than the semaphores actually installed on this line. The protection which it affords is, of course, complete, but it rigidly compels the spacing of trains one block apart, or in this case from siding to siding, and where traffic requirements make this undesirable the scheme shown in Fig. 4 is recommended if conditions are suitable. Five Indiana interurban railways are installing signals in accordance with this scheme at the present time.

This is based upon the same general plan as the foregoing one, except that light signals are used, but it provides for permissive following movements in order to eliminate the necessity for trains in the same direction to be spaced a full block-length apart. The two upper lights constitute the main signal and a lower light the permissive indication.

This method of operation is, in many classes of service, eminently satisfactory, although the manufacturer by no means claims that it is universally desirable under all conditions, and where permissive blocking is not desirable the use of multiple intermediate signals or a decreased block length is recommended instead.

Operation under permissive following movements, while not generally regarded with favor for extremely high-speed service, is acceptable to many operating men for ordinary electric railway traffic, and the adherents of such methods point to the New York elevated roads, which have operated for twenty-five years with practically no following movement signals and with no serious collisions. There is, of course, no question that train movement may thus be accelerated under many circumstances. In the Indiana installations, it should be said, distant signals which are repeaters of the home signal in advance are installed wherever a clear view of the home signal cannot be obtained at a sufficient distance to avoid reducing speed.

The permissive feature of the plan shown in Fig. 4 necessitates the use of switch indicators at the sidings, as the existence of a train in any block is no guarantee that the portion of the block at its rear is clear.

The switch indicators developed for this scheme possess an astonishing indicating ability. If trains approach the switch from either or both directions, a stop indication is given by the indicator, but if the blocks on either side of the indicator are clear, or if trains are in them but are receding from the switch in either direction, the switch indicator displays a clear indication and permits the train to move out into the main line. One of the greatest advantages of this device is the fact that it gives full information to trainmen with its one indication, and in consequence the motorman does not have to look at the signals and think out whether the combination of indications displayed makes it safe for the train to move out of the siding. Another advantage obtained through the use of this device exists where light signals are used in place of semaphores. In this case, as mentioned before, the cost of current for the lamps and the deterioration of the lamps themselves constitute a serious expense, so that the high-power lamps are extinguished when a train leaves a block. Such an arrangement would leave no main signals to govern a car on a siding as it would be necessary for the car to be on the main line before the signals would be illuminated, and here the switch indicator provides the way out of the difficulty by giving an indication independent of the condition of the lights on the high signals. To prevent simultaneous movements of trains from a siding and into the block at the other end time elements are used with the switch indicators, compelling the lapse of a fixed interval of time between throwing the switch and the receipt of the indication.

Another novel feature developed for this signaling scheme is the block indicator, represented in Fig. 4 by a pair of concentric circles. This is a single light mounted on one of the poles at the beginning of the preliminary, and it is connected through the signal near the siding at the end of the preliminary, thus being illuminated whenever the block is occupied. In consequence, a car ap-

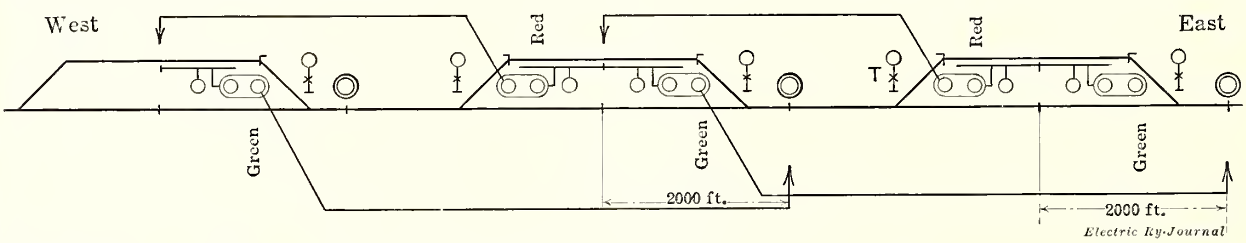


Fig. 4—Arrangement of Light Signals Having Permissive Indications for Following Movements, Switch Indicators and Block Indicators at the Commencements of the Preliminaries

proaching the preliminary at a siding where a meet has been ordered waits at the block indicator until it is illuminated, being thus informed that the opposing train has entered the opposite end of the block and can no longer be interfered with by an opposing train which gets on to the preliminary track section. The excellence of the device aside from its simplicity lies in the fact that it eliminates the illogical procedure, previously followed, of using a distant signal at the commencement of the preliminary to serve the same purpose; for an approaching train, finding the distant signal at clear, would have to wait until it went to caution before proceeding to the siding.

One of the features of this scheme is the use of but three line wires for opposing signals, and this assists materially in reducing the cost of installation. The cost is, however, considerably greater than that of the scheme outlined in Fig. 3, as the provisions for accelerating traffic are very much more elaborate and they naturally involve a proportionately higher cost. The scheme may be considered as the most recent of the General Railway Signal Company's developments for signaling interurban roads with moderately dense traffic.

TRACK-CIRCUIT SIGNALING WITHOUT PRELIMINARIES

In several suggested schemes for electric railway signaling the elimination of preliminaries has been accomplished by the use of intermediate signals, as these serve equally well to stop opposing trains in the rare case when they happen to enter opposite ends of the block at the same instant. This principle was, however, actually used for the first time in the now well-known installation made on the Washington, Baltimore & Annapolis Railroad in 1912 by the Union Switch & Signal Company. The arrangement of signals is shown in Fig. 5. In this each block is self-contained and a normal-clear home signal is located at each end and controlled by the track circuit of the entire block. In addition to these home signals two advance intermediate signals are located about 1000 ft. inside of the respective home signals. Each of these signals, however, is controlled only by the track in the opposite half of the block, the actual control extending from the opposite end to about 1000 ft. beyond the center of the block. In other words, each intermediate signal is about 1000 ft. in advance of the home signal but is at a considerable distance to the rear of the track by which it is controlled. An intermediate is therefore not affected by an approaching car until some time after it has been passed. The opposite intermediate is, however, set at stop as soon as the car enters the block. In operation, therefore, a car which enters the block sets both home signals and the farther intermediate at stop. After it reaches a point about 1000 ft. from the center of the block all four signals are set at stop, the whole block clearing up when the car leaves it.

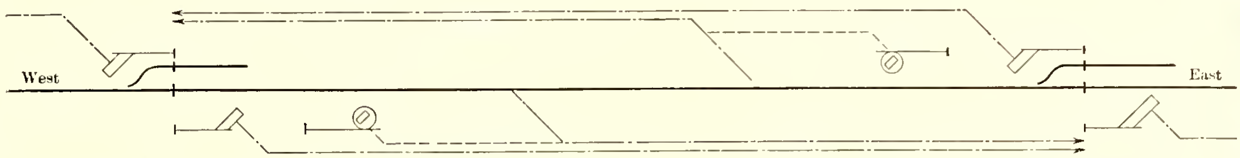


Fig. 5—Signal Arrangement Used on Washington, Baltimore & Annapolis Railroad to Effect the Elimination of Preliminaries

For an arrangement where a spacing of a full block is required for following movements this scheme works out exceptionally well and it may be installed at a comparatively moderate cost. Another and much more recent scheme of the same manufacturer is shown by Fig. 6, the plan which has been adopted by five of the Indiana interurban roads for the installations purchased during the early part of the present summer.

In this scheme protection against simultaneous entrance of the block by opposing trains is also obtained by intermediates as in the foregoing plan. These intermediates are, however, located near the center of the block, being staggered so as to give a spacing of about 3000 ft., thus providing a stopping distance for opposing trains which might run by them. In consequence, the arrangement differs from that outlined in Fig. 5 by the fact that the distance between each home signal at the end of block and its intermediate is greatly increased.

Each block, siding to siding, is one center-fed track circuit having two track relays, one at each end. Each track relay is controlled by cars which are on that part of the track between the location of the relay and a point about 1000 ft. beyond the center of the block. Therefore, there is a space of about 2000 ft. in the center of the block in which a car would control both relays. The two home signals at the ends of the block are mutually operative through both of the track relays so that when a car enters either end of a block both signals assume the stop position, preventing the entrance of an opposing car. Thus as a car enters the block the track relay at the

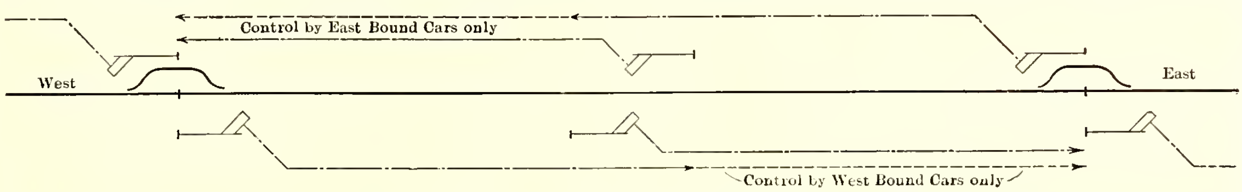


Fig. 6—Latest Development of Single-Track Signaling Without Preliminaries, Permitting Following Movements Under Spacing of One-half Block Length

entrance end sets the opposing intermediate signal to the stop position, and a circuit controller on this signal opens the circuit for the opposing home signal at the other end of the block and sets it to stop. In consequence, the entering car is protected against opposing trains by two signals, one

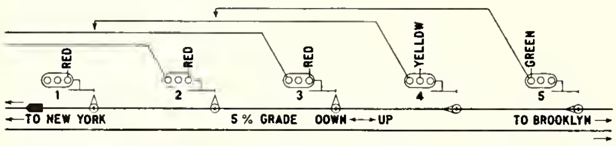


Fig. 7—Signal Arrangement on Williamsburg Bridge, New York Municipal Railways—Two Blocks Overlap and Speed Control on Down-Grade

at the end and one near the center of the block. The intermediate signal which is being approached by the car is, however, left in the clear position until the car reaches a point about 1000 ft. from the center of the block, when the track relay at the other end is de-energized and the signal goes to the stop position. At about the same time the home signal which was passed when the car entered the half of the block which is in advance of it, as well as by the opposing home signal in front, because the track relay at the advance end of the block is de-energized as long as a car is in that part of the block.

Cars may operate into and out of sidings as desired, and when in the clear, on the siding, they do not affect the signals so that sidings may be passed at high speed.

Considering the traffic that may be handled under this arrangement, the first cost is very moderate, although it is somewhat greater than that of the previously described scheme. Two position signals are being used in the first of the installations of this type, but light signals may, of course, be used instead if they are desired for reasons of further economy. One reason for the moderate cost is the use of but one track section to each block notwithstanding the presence of intermediate signals. Consequently, for high speeds and a traffic density that does not require more than two following cars between sidings this scheme offers obvious advantages, as the desideratum of expense is a most important one providing the demands of traffic are met in a satisfactory manner.

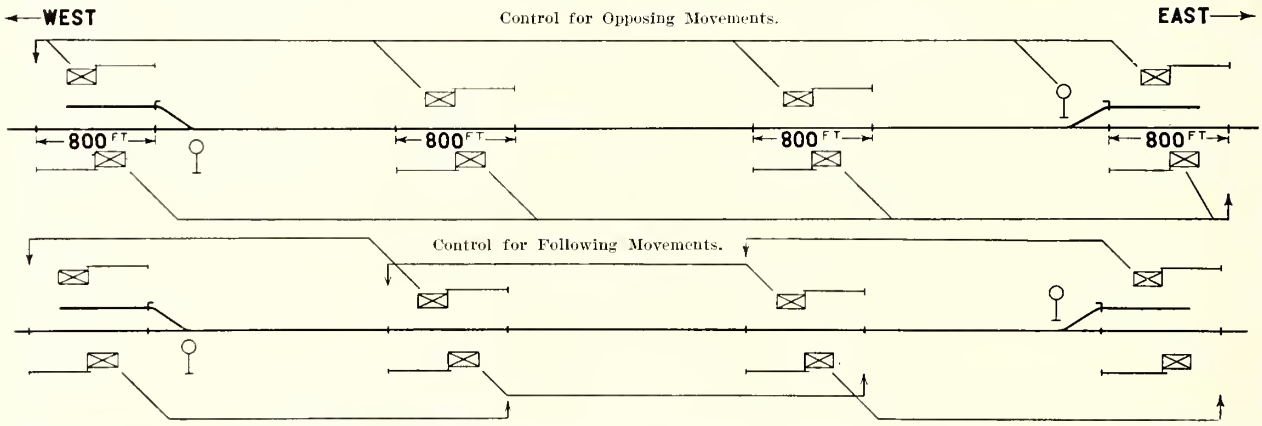


Fig. 8—Diagram Showing Limits of Signal Control for Opposing and for Following Movements, Rochester & Eastern Railroad

the block is cleared up, this being accomplished through the use of a so-called stick relay, but since the home signal at the other end is controlled by the track relay at that end it is not cleared at this time, and it thus maintains protection against opposing movements into the block.

However, when the car has passed the center of the block the clearing of the home signal in the rear or at the entrance end permits the entrance of another car, thus pro-

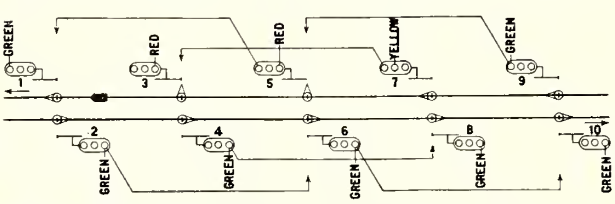


Fig. 9—One Block Overlap and Automatic Stops on Center Street Loop, New York Municipal Railways

viding absolute blocking for following movements under a spacing of half a block length, consequently accelerating the movement of traffic in direct proportion. In this case the first car is protected in the rear by the proper intermediate signal, as this is controlled by the track relay in

BLOCKING WITH MULTIPLE INTERMEDIATE SIGNALS

For great density of traffic together with extremely high speeds the installation which is being made for the Rochester & Eastern Railway may be said to be the most complete single-track signal scheme yet planned for electric railways. The general arrangement is shown in Fig. 8. It will be noted that each block is self-contained and symmetrical, no preliminaries being used. The entering signal for each block is called the starting signal, and when this is passed by a car entering the block the action of this signal in moving to danger causes the starting signal at the other end of the block to go to danger also, taking with it all of the intermediate signals which cover the opposing movement.

The intermediate signals which govern the movement of the car after it has entered the block do not, however, go to danger until they have been passed by the car.

The signals are three-position and provide cautionary indications at 45 deg. for the signal in advance, the signal in the rear obtaining at the same time its clear position from the same operation. In consequence, a warning is always given one track section in advance of a danger signal except in the case where two trains effect simultaneous entrance into a block with only two intermediate signals. In this case the intermediate signals are staggered 1500 ft., giving each car practically full stopping distance after passing its signal.

With more than one pair of intermediates the spacing for the stagger is, however, made 800 ft., and the control of each track section extends beyond the home signal to the opposing signal in advance, thus providing an overlap for following movements equal to the full stopping distance.

The scheme provides for following movements with a spacing of one-third or one-fourth of the block length, warning indications by distant signals and overlaps in accordance with the best practice in double-track signaling. Apparently nothing is left to be desired. The expense is, however, very heavy, the estimated first cost with blocks about 4000 ft. in length being in the vicinity of $2,600 per mile of track.

AUTOMATIC STOPS AND SPEED CONTROL

The double-track installation on the New York Municipal Railways Corporation on the Centre Street loop subway and Williamsburg Bridge, New York City, which has just been placed in service, is the most recent installation of automatic stops on electric railways. It is a good example of intensive signaling. All of the principal refinements of modern signal practice are utilized—automatic block signals, automatic stop, automatic speed control, electric interlocking and illuminated track diagrams.

The speed-control system was installed on the bridge approach, in addition to the automatic signals and stops, to prevent a train on the heavy grade from exceeding a speed of 20 m.p.h. The signals on the bridge are normal-stop, but in the subway, which does not require speed control, the signals are normal-clear. Arrangements of typical sections are shown in Fig. 7 and Fig. 9.

All signals in the subway and on the bridge are light signals, those on the bridge being hooded. Each block signal has three 5-in. lenses, green for clear, yellow for caution and red for stop, placed one above the other.

The automatic stop has a tripping arm, located outside of and adjacent to one of the rails at each signal, and this engages a special valve mechanism on the motor car when a stop signal is over-run. When the signal indicates proceed, the tripping arm is in such a position that it does not engage the air valve on the motor car.

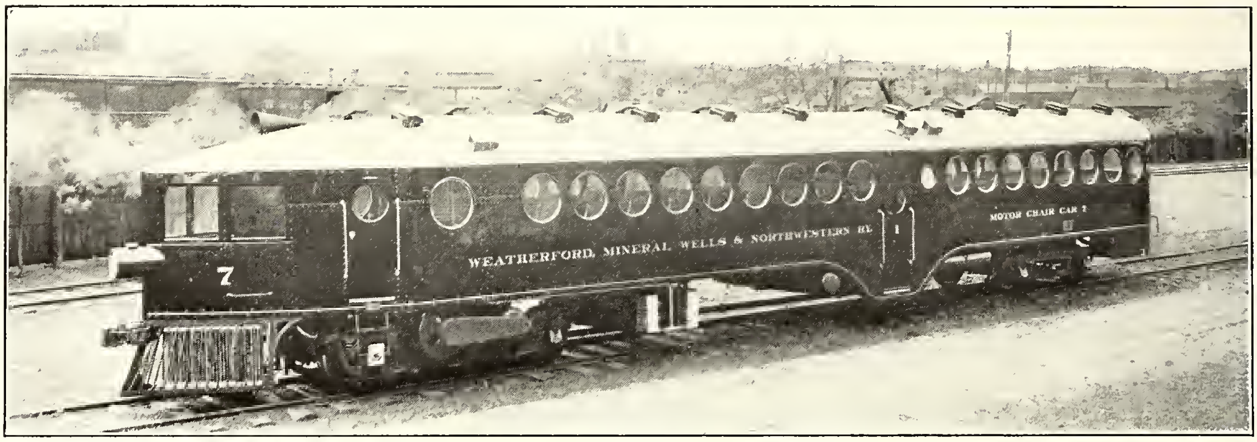
View Showing Three-Indication Signals for Main and Diverging Routes at the Right and Trip for Automatic Stop and Speed Control at the Left, Inter-Bridge Loop, New York Municipal Railways

The operation of the speed-control system is accomplished by means of a time element or slow-acting device in the control circuit. This is operated by an approaching train and closes the control circuit for the next signal in advance of the train in a predetermined time, corresponding to the time required for a train to pass through the block at a speed of 20 m.p.h. If this speed is exceeded, the control circuit is still open when the train reaches the signal. The signal therefore still shows stop and the arm is in position to engage the air valve on the car and stop the train.

SELF-PROPELLED CARS

WHILE the self-propelled car has a lineage almost as old as that of the steam locomotive, it has long since ceased to be a serious rival either of the locomotive or of the much younger trolley car. It is true that the auto-vehicle of to-day embodies great technical advances on the steam, air and ammonia cars of earlier times. But it is also true that there has been a parallel advance in the technic of the locomotive and of the electric railway which receives power direct from a central station. The attempt to conduct cross-country transportation on a large scale by the self-propelled car was abandoned in the forties when it was shown that trackless "steamers" were far costlier than trains on rails, and in a similar way the heavy service of city transportation was surrendered by the storage battery to the trolley car about half a century later. Yet, if these fields of greater traffic were lost, many opportunities for usefulness remained and still others were created as the benefits of the various modes of transit became better known. It is this condition which has justified the continued development and successful exploitation of gasoline, gas-electric and storage battery cars.

It would be easy to present a category of actual and possible conditions for which the self-propelled car is suitable, but the variety of applications will be still more impressive if the installations already made are allowed to tell their own story. From this variety it is possible to secure data for fairly definite conclusions on the merits of each type for particular classes of service. As the following account tends to show, both the gasoline and the gas-electric type are readily capable of running 150 miles a day and more, whereas the limitations of battery weight, facilities for charging and limitations of schedules confine the accumulator car to city and short-line operation. In presenting this list of installations and tables of operating statistics it has been thought well to refer only to the representative builders of self-propelled cars rather than to include descriptions of more or less experimental designs.



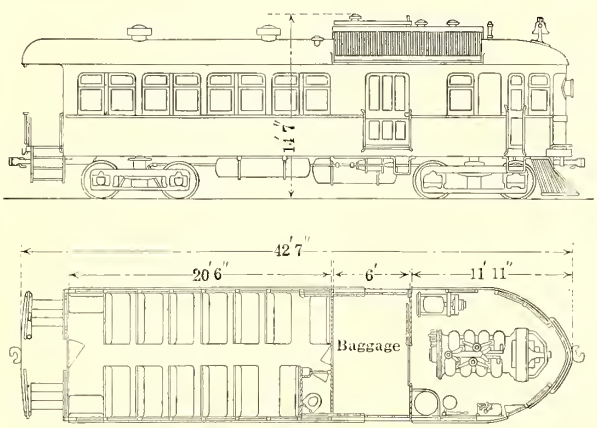
Direct-Driven Gasoline Motor Car of All-Steel Construction

Gas-Electric Passenger and Baggage Car, 70 ft. Long, with Rear Platform Entrance

GASOLINE CARS

The McKeen steel motor car was developed about ten years ago for service on the less important branches of the Union Pacific Railroad. Its conspicuous success has led to its adoption for similar service on other railroads, so that to-day some 139 cars, comprising all that have been built by the McKeen Motor Car Company, are in use on fifty systems. Among the American users are the Erie Railroad, the Virginia & Truckee Railroad, the Denver, Laramie & Northwestern Railroad and the Norfolk & Western Railway, while five and two cars respectively have been sold to the Queensland and Victorian railways of Australia. The accompanying Table I is of exceptional interest as it shows what results can be obtained with straight gasoline cars after four to seven years' steady service. According to the manufacturing company, these figures include all the expenses of operation and maintenance. The manufacturer believes 3 per cent per annum to be a conservative maintenance charge on these equipments in view of the durable all-steel construction of the car bodies, the substantial trucks and the use of the best available gasoline machinery.

An inspection of Table I reveals immediately the character of operation for which these cars are used. The cars are from 55 ft. to 70 ft. long, carry 200 hp in engine equipment and run from 122 miles to 204 miles a day at schedule speed, between 19.8 and 26.5 m.p.h. The shortest distance between stops, regardless of cross-roads, is 4 miles, and the longest distance between stops is 21 miles. The maximum grade is 1.9 per cent. The highest operating and maintenance cost, 19.33 cents per mile, is shown by the system with one stop per 5 miles; the lowest operating and maintenance cost, 12.28 cents per car mile, with a car of the same length making one stop about every 7 miles. With one exception, the general character of operation with these cars is to make one round trip a day. On dividing the schedule speed into the daily revenue mileage, it will be found that the cars run only eight or nine hours a day, so that ample time



Typical Gas-Electric Motor Car for Use with Trailing Loads

is available for layovers and inspection even with performances of 200 miles.

DRAKE GAS-ELECTRIC CARS

The automotrice, or so-called "Dracar," of the Drake Railway Automotrice Company, was introduced in the United States in 1912 after its development and extensive installation abroad, notably on the Arad Csanad Railway, Hungary; Ostdeutsche Railway, Germany, and Great Central Railway, England. On the Arad line the service has grown from 67,017 train miles in 1903 to 1,000,000 train miles in 1912. In 1912 the same railway operated 952,143 train miles at an average cost of 7.62 cents per train mile, made up of the following components: gasoline, 3.66 cents; oil and waste, 0.33 cent; helpers and sundries, 0.75 cent; lighting, heating

Automotrice for High-Speed Service with Passenger and Baggage Compartments

and cleaning cars, 0.23 cent, and maintenance, 2.65 cents.

The forty-four-passenger 56-ft. car is furnished with a 90-hp gas-electric set and standard 500-volt railway motors, permitting a schedule speed of about 25 m.p.h. and a maximum of 40 m.p.h. The 60-ft. and 70-ft. cars, seating respectively sixty-eight and ninety-one passengers, are each equipped with a 150-hp gas-electric set, permitting a schedule speed of 30 m.p.h. and a maximum

TABLE I—OPERATING DATA ON MCKEEN GASOLINE CARS AS OF JULY 18, 1913

	Car "A"	Car "B"	Car "C"	Car "D"	Car "E"	Car "F"
When shipped	1906	1906	1906	1909	1908	1907
Type	55 ft. Steel, 200-hp	55 ft. Steel, 200-hp	55 ft. Steel, 200-hp	70 ft. Steel, 200-hp	55 ft. Steel, 200-hp	55 ft. Steel, 200-hp
Weight, lb.	60,000	60,000	60,000	68,000	60,000	60,000
Terminal points of route	AA-A	AB-B	AC-C	AD-D	AE-E	AF-F
Miles of route	61	39.7	102.3	39	95.7	80.5
Daily revenue mileage	122	148.8	204.6	176	191.4	161
Schedule speed, m.p.h.	19.8	26.5	25.1	22.3	23.4	21.7
Number intermediate stops	14 and cross-roads	7 and cross-roads	15 and cross-roads	5 and cross-roads	23 and cross-roads	16 and cross-roads
Maximum grade, per cent	0.8	1.6	0.5	0.3	1.9	0.9
Trailer	No	No	Yes	Yes	No	Yes
Operating and maintenance cost in cents per mile, seven-month period	13.47	14.81	12.28	14.83	15.41	19.33

of 50 m.p.h. The cars range in weight from but 30 tons to 37 tons, and this with their moderate speed allows a run of from 2½ to 3½ miles on 1 gal. of gasoline. A variation of this type of equipment is afforded by the Drake passenger tractor, which combines the functions of a locomotive and a passenger car, since it can be used either to handle freight at slow speeds or passenger service at speeds as high as 50 m.p.h.

The first American installation of the "Dracar" was made in November, 1912, on the Missouri, Oklahoma & Gulf Railway on a 105-mile line between Joplin, Mo., and Denison, Tex. This line is paralleled on one side by the Missouri, Kansas & Texas Railway and on the other by the St. Louis & San Francisco Railway. The longest run is a single round trip of 210 miles a day. The five cars are of wooden construction, 56 ft. over all, and comprise a 30-ft. compartment for white passengers, a fourteen-seat compartment for colored passengers, a baggage compartment, combined engine and control room at one end and control cab alone at the opposite end. The cars are operated double-ended to obtain the utmost flexibility in operation. To reverse his car the motorman leaves the gasoline engine running under reduced speed and merely carries the controller handle to the other cab just as on a trolley car. Where short stops are made the engine is throttled down only. The engine is started by cranking, just like an automobile motor. In obedience to state commission regulations it is necessary to use three men per car, namely, a motorman, a conductor and a flagman. One inspector is also employed. Table II covers operating data on this installation from December, 1912, to April, 1913, as prepared by the auditor of the railway company. These figures show a gradual reduction in the cost per car mile to 16.4 cents.

Table II—Operating Costs of Five Gas-Electric Cars on Missouri, Oklahoma & Gulf Railway

	Nov.	Dec.	Jan.	Feb.	March	April
Mileage:						
No. car miles...	2,350	7,130	9,390	12,858	22,352	18,336
Wages:						
Motormen.....	$91.20	$248.00	$392.72	$493.02	$814.64	$676.44
Conductors....	77.26	244.00	277.63	406.39	620.80	548.14
Flagmen......	43.13	136.20	149.50	214.06	323.90	288.75
Supervision:						
Inspector.....	6.40	125.00	125.00	125.00	125.00	125.00
Fuel, etc.:						
Gasoline, gal...	684	2,050	3,080	5,515	7,406	5,483
Gasoline, cost..	$112.92	$328.10	$513.20	$917.27	$1186.52	$877.30
Lub. oil, pints..	582	612	1,088	1,057	3,748	3,139
Lub. oil, cost...	$17.45	$19.87	$71.67	$53.58	$139.86	$119.10
Supplies......	14.67	45.66	67.57	65.25	74.91	35.67
Repairs:						
Running......	$40.52	$130.02	$152.06	$35.401	$325.37	$167.30
Expense:						
Shop expense...	$130.88	$93.50	$116.79	$164.48	$153.74	$175.63
Total expense.	534.45	1420.35	1866.14	2793.76	3764.83	3023.33
Revenue:						
Total revenue..	$1136.43	$3576.74	$3872.12	$4955.46	$9249.39	$8850.62
Net revenue...	601.98	2156.39	2005.98	2161.70	5474.56	5827.29
Passengers:						
No. rev. pass....	2,230	7,377	6,085	9,937	18,718	15,972
Pass., 1 mile...	38,710	126,428	122,325	169,260	326,901	323,890
Gross rev. per pass........	$0.510	$0.485	$0.479	$0.488	$0.494	$0.435
Net rev. per pass........	0.256	0.302	0.239	0.168	0.244	0.328
Miles:						
Per gal. gas....	3.4	3.5	2.7	2.3	3	3.3
Per pt. oil.....	4.0	12.0	7.7	12.2	5.9	6.0
Cost per mile in cents:						
Wages........	$0.093	$0.095	$0.098	$0.086	$0.079	$0.082
Inspection.....	0.003	0.018	0.015	0.009	0.005	0.007
Gasoline......	0.049	0.046	0.065	0.071	0.053	0.048
Lubricating oil	0.007	0.003	0.006	0.004	0.006	0.006
Supplies......	0.006	0.007	0.008	0.005	0.003	0.003
Repairs.......	0.017	0.018	0.018	0.027	0.016	0.011
Shop expense..	0.052	0.013	0.013	0.013	0.007	0.010
Total cost per car mile.....	$0.227	$0.200	$0.223	$0.217	$0.169	$0.164

GENERAL ELECTRIC GAS-ELECTRIC CARS

The gas-electric cars of the General Electric Company comprise three classes as follows: Center-entrance ("CE"), rear entrance ("RE") and center and rear entrance ("CRE"). Practically all cars have a 12-ft. engine compartment. In the combination cars the length of the baggage and mail compartments, "B" and "M," varies from 8 ft. to 15 ft. The smoking compartment is usually 6 ft. to 12 ft. long. At this time the company has in operation some sixty-two cars on twenty properties.

For convenience in tabulating the characteristics of the cars to date they are classified partly according to the initials already quoted and partly according to their dimensions. Thus RE-70-B-13-M-10 signifies a rear-entrance car 70 ft. long and including a 13-ft. baggage and 10-ft. mail compartment. All of these cars were built at the works of the Wason Manufacturing Company, Springfield, Mass., but were equipped by the General Electric Company.

Tables III, IV, V and VI as furnished by the manufacturer embody the most comprehensive data as yet prepared on this subject. Table III shows the conditions under which sixty cars are operated on twenty railroads in the United States. The Frisco Lines alone operates fourteen cars. The second in importance is the Minneapolis, St. Paul, Rochester & Dubuque Electric Traction Company with twelve cars. As a rule, the G.E. cars are operated on routes more than 50 miles in length and make one round trip a day with a maximum performance of 246 miles. The stops are from 1 mile to 7.5 miles apart and the schedule speed ranges from 14.5 m.p.h. to 29 m.p.h. On most lines the grades are easy, but in one instance a grade of 3 per cent is encountered. The ability of the gas-electric set to take care of overloads is illustrated by sixteen instances of trailer operation.

Table IV covers the operations for the calendar year 1912 of the Minneapolis, St. Paul, Rochester & Dubuque Electric Traction Company, popularly known as the "Dan Patch" line. The incorporated name of this company indicates its ultimate operation as an electric interurban railway, but so far the self-propelled cars have proved satisfactory. This line with local stops but 1 mile apart approximates regular interurban service very closely. The average cost of operation and maintenance was 18.08 cents per motor-car mile, and 13.38 cents per total car mile, trailers being used very extensively on this line.

Table V and VI respectively cover the operation of six and fourteen cars of the Frisco Lines, where the stops are much farther apart than on the "Dan Patch" line. The costs for the two groups are 16.61 cents and 17.31 cents per motor-car train mile respectively.

STORAGE BATTERY CARS

The present development of the storage battery car in the United States comprises some forty-five installations and 280 cars. Of these the Third Avenue Railway, New York, with 160 cars, operates more self-propelled units than all the other installations combined. The next larger installation is one of forty-five cars which has just been made for the New York Railways. No other company is operating more than six cars. Excepting the New York installations, which were due to the prohibitive cost of conduit construction for lines with weak traffic, it appears that the storage battery car has been applied only to very small roads and to some short low-travel branches of trunk-line steam railroads. However, these small applications fill needs of such diverse character that one may reasonably expect to see scores, if not hundreds, of similar installations in the near future. Broadly speaking, in the United States the accumulator car has found a place for service in small towns with cheap current, for real estate development and for short interurban lines; in Latin-American, and possibly other, countries it may be applied to old streets which are considered too narrow for safe use of an overhead wire, and finally it is used for short steam railroad lines radiating from cities as found in the extraordinary network of the Prussian State Railroads.

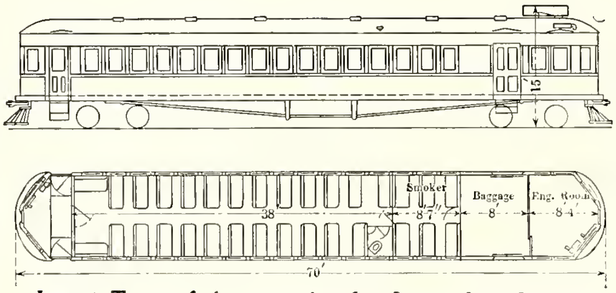
Two distinct types of storage batteries are used in this country, the lead and the nickel-iron. Both have shown

TABLE III—GENERAL ELECTRIC GAS-ELECTRIC PASSENGER CARS IN SERVICE

Railway	No.	Type	Seats	Wght. Tons	Shipped	Where Used	Miles Route	Max. Grade	Daily Reven. Mileage	Sched. Speed, M.P.H.	No. of Interm. Stops
Southern	1	CRE-55	52	41	2–11	Greenville-Anderson, S. C.	37	1	170	18½	34
Southern[1]	1	CRE-55	52	41	4–11	Memphis-Collierville, Tenn	25	1	100	21½	18
Buffalo, Rochester & Pittsburgh[2]	1	CE-66-B-6	90	46	4–11	Buffalo-Springville, N. Y.	32	..	128	22½	..
Minneapolis, St. Paul, Rochester & Dubuque Traction	1	RE-50-B-5	44	32	12–10	Minneapolis-Northfield	37.34		See Table IV		
Minneapolis, St. Paul, Rochester & Dubuque Traction	2	CE-58-B-8	47	41	5–11	Minneapolis-Northfield	..	..	..	..	..
Minneapolis, St. Paul, Rochester & Dubuque Traction	1	RE-57	88	39	6–11	Minneapolis-Northfield	..	..	..	..	..
Minneapolis, St. Paul, Rochester & Dubuque Traction	1	RE-57-B-6	75	40	7–11	Minneapolis-Northfield	..	..	..	..	..
Minneapolis, St. Paul, Rochester & Dubuque Traction	1	RE-67-B-11	88	46	3–12	Minneapolis-Northfield	..	..	..	..	..
Minneapolis, St. Paul, Rochester & Dubuque Traction	2	RE-70-B-11	91	49	5–12	Minneapolis-Northfield	..	..	..	..	..
Minn., St. P., Roch. & Dub. Tr.	1	"Marion"	...	49	5–13	Minneapolis-Northfield	..	..	..	..	.
Minn., St. P., Roch. & Dub. Tr.	2	RE-70-B-11	91	49	8–13	Minneapolis-Northfield	.	..	..	..	..
Frisco Lines	1	CRE-70-B-8	86	50	9–11	Muskogee-Westville, Okla.	72	1½	144	20½	15
Frisco Lines[3]	1	CRE-70-B-8	86	50	10–11	Lawton, Okla.-Quanah, Tex.	94	1	188	22	15
Frisco Lines	1	CE-70-B-11	91	52	3–12	Dallas-Sherman, Tex.	76	1¼	152	24¾	18
Frisco Lines[4]	1	CE-70-B-11	91	52	3–12	Bolivar-Chadwick, Mo.	73	2.3	146	20	19
Frisco Lines[3]	1	CE-70-B-11	91	52	4–12	Kansas City-Clinton Mo.	87	2½	174	22	28
Frisco Lines[3]	1	CE-70-B-11	91	52	4–12	Enid-Clinton, Okla.	94	1½	188	23½	12
Frisco Lines[3]	1	CRE-70-B-8	86	50	8–11	Cape Girardeau-Poplar Bluff, Mo.	64	..	128	20	25
Frisco Lines	1	CRE-70-B-8	86	50	6–11	Brownsville-Sam Fordyce, Tex.	78	0	156	22	17
Frisco Lines[3]	1	CRE-70-B-8	86	50	9–11	Orange-Newton, Tex.	62	0	124	18	16
Frisco Lines[5]	1	CE-70-B-11	91	52	7–12	Fort O'Connor-Victoria-Austwell, Tex.	70	0	204	21	10
Frisco Lines[6]	1	CE-70-B-11	91	52	8–12	Houston-Beaumont, Tex.	89	0	178	22	17
Frisco Lines[7]	1	CE-70-B-11	91	52	7–12	New Orleans-Shell Beach, La.	29	0	116	14½	15
Frisco Lines	1	CE-70-B-11	91	52	9–12		Excursion service				
Frisco Lines	1	CRE-70-B-8	86	50	7–11		spare equipment				
New Iberia & Northern	2	CE-70-B-11	91	52	6–12 8–12	Port Barre-Shady Side, La.	89	0	178	18	12
Quanah, Acme & Pacific	1	CE-70-B-11	91	52	8–12	Quanah-Paducah, Tex.	43	1	86	17	6
Bangor & Aroostook	1	CE-66-B-6	97	47	8–11	Fort Kent-Squa Pan, Me.	109	..	218	27	26
Bangor & Aroostook	1	CE-68-B-10½	91	48	3–12	Greenville-Brownville Junction, Me.	58	..	116	26	22
Delaware & Hudson	1	CE-68-B-10½	91	46	12–11	Delanson-Mechanicsville, N. Y.	32	1	128	27	7
Canadian Northern	1	RE-57-B-6	76	40.5	4–12	Picton-Trenton-Napanee	60	..	120	..	..
Missouri Pacific	1	CRE-70-B-11	85	51	5–12	Butler, Mo.-Madison, Kan.	108	1.2	216	22	21
Missouri & North Arkansas	1	CRE-70-B-11	85	51	9–12	Eureka Springs, Ark.-Joplin, Mo.	79	2.6	234	24	14
Missouri & North Arkansas[8]	1	CRE-70-B-11	85	51	9–12	Heber Springs-Helena, Ark.	116	1	241	21	16
Chicago, Rock Island & Pacific	1	CE-70-B-13½	79	51.5	10–12	Enid-Anadarko, Okla.	123	1	246	20	19
Chicago, Rock Island & Pacific[9]	1	CE-70-B-13½	79	51.5	10–12	Eunice-Alexandria, La.	56	..	112	22	12
Pittsburgh & Lake Erie[10]	1	RE-42-B-6	42	39	11–12	Pittsburgh-College, Pa.	31	0	154	25	18
Texas Midland	2	CRE-70-B-2½	101	52.5	10–12	Dallas-Paris, Tex.	116	1	232	26	24
Great Northern	1	CRE-70-B-11	86	52	2–13	Burlington-Anacortes, Wash.	17	..	102	20	5
Great Northern[11]	1	CRE-70-B-11	86	52	2–13	Minneapolis-Mound, Minn.	22	1.75	88	26	10
Chicago, Milwaukee & Puget Sound	1	CE-69-B-15	77	51	11–12	Everett-Monroe, Wash.	14	..	70	21	6
Chicago, Milwaukee & Puget Sound	1	CE-69-B-15	77	51	12–12	Seattle-Enumclaw, Wash.	62	3	124	24	16
Chicago, Milwaukee & St. Paul	1	RE-70-B-15	80	51	12–12	Seattle-Enumclaw, Wash.	62	3	124	24	16
Chicago, Milwaukee & St. Paul	1	RE-70-B-15	80	51	12–12	Waukum Junction, Dubuque, Ia.	62	..	124	..	..
Chicago, Milwaukee & St. Paul	1	RE-70-B-15	80	51	12–12	Wabasha-Faribault, Minn.	94	..	188	..	..
Chicago, Milwaukee & St. Paul	1	RE-70-B-15	80	51	12–12	Racine-Corliss, Wis.	7.4	..	103.6	..	..
Chicago, Milwaukee & St. Paul[12]	1	RE-70-B-13-M-10	60	52.5	3–13	Hastings-Cologne, Minn.	56	..	112	17	18
Pere Marquette[13]	1	RE-70-B-11	91	49	4–13	Bay View, Clary, Mich.	98	..	146	..	..
Chicago, Peoria & St. Louis[14]	1	RE-70-B-11	91	49	5–13	Springfield, Ill.-St. L., Mo.	112½	..	228	.	31
Chicago, Peoria & St. Louis[15]	1	RE-70-B-11	91	49	5–13	Palmyra-Peoria, Ill.	122	..	224	.	33
Chicago, Peoria & St. Louis[14]	1	RE-70-B-11	91	49	5–13	Peoria-Springfield, Ill.	88	..	176	..	24
Chicago, Peoria & St. Louis[15]	1	RE-70-B-11	91	49	6–13	Springfield, Ill.-St. L., Mo.	112½	..	226	..	31
Atchison, Topeka & Santa Fe	1	CE-68-B-10	89	50½	6–13	Holliday to Atchison, Kan.	60	..	..	..	8
Atchison, Topeka & Santa Fe[16]	1	CE-68-B-10	89	50½	7–13	Emporia to Gridley, Kan.	112	..	224	22.4	10
Midland Valley	1	CRE-70-B-11	86	52	7–13	Wichita-ArkansasCity, Kan.	51	..	102	18.5	13

[1]Hauls a 22-ton trailer. [2]Hauls milk car morning and evening trip. [3]Hauls a 23-ton trailer. [4]Route has 4 miles of 2 per cent continuous grade; hauls 25-ton trailer 66 miles daily. [5]Ten stops in 52 miles. [6]Hauls 20-ton trailer. [7]Hauls two trailers weighing 45 tons 13 miles each day. [8]Hauls 16-ton trailer. [9]Hauls 25-ton trailer two days a week. [10]Hauls 23-ton trailer. [11]Hauls 47-ton trailer. [12]Hauls combination baggage and mail car. [13]Hauls 35-ton trailer. [14]Hauls 27½ ton trailer. [15]Hauls 29-ton trailer. [16]Hauls 33-ton trailer.

suitability for traction purposes, although they differ much in their characteristics. It is unnecessary to describe their differences, but it is desirable to point out the conflicting advice given by the manufacturers to railway operators. One battery maker suggests an accumulator which will be large enough to do a day's work without



Latest Type of Automotrice for Interurban Service

intermediate normal or high-rate charging; another suggests a small battery which can be replenished by boosting charges during layovers and by normal charges at night. The buyer of accumulator cars, therefore, should make certain that the batteries which are offered to him will meet exactly the same schedule. It would be unwise to purchase a battery of excessive weight and ca-

Table IV—Operating Data of Minneapolis, St. Paul, Rochester & Dubuque Electric Traction Company—"Dan Patch Line"—Jan. 1, 1912, to Jan. 1, 1913.

Total motor car miles	216,498
Total trailer car miles	75,948
Total car miles	292,446
Per cent of time trailers hauled	35.5
Number of motor cars in service	8
Length of line	37.34
Maximum grade, per cent	1.5
Average grade for 4 miles, per cent	1.34
Schedule time for express trains	1 hr. 17 min.
Average distance in miles between express stops	3.734
Schedule speed of express trains, m.p.h	29.1
Schedule time for local trains	1 hr. 35 min.
Average distance between local stops, miles	1.067
Schedule speed of local trains, m.p.h	23.6
Fuel per motor car mile, gal	0.758
Fuel per car mile	0.527

	Total Cost for Year	Average Cost per Motor Car Mile	Average Cost per Car Mile
Wages of crew	$12,056.95	$0.0557	$0.0412
Fuel (naphtha)	17,622.26	0.0814	0.0603
Lubrication (gas engine)	1,141.56	0.0052	0.0039
Journal oil	77.77	0.0004	0.0003
Supplies and car heating	1,389.03	0.0064	0.0047
Maintenance electrical equipment	1,949.81	0.0090	0.0067
Maintenance cars and trucks	1,349.56	0.0065	0.0047
Shop expenses and heating	3,507.77	0.0162	0.0120
Total	$39,139.71	$0.1808	$0.1338

pacity, but it is equally important to select a battery which will fit the service instead of requiring the service to fit the battery. It follows that a fundamental factor in the choice of the type and capacity of the storage battery is the amount of proper layover time during the day.

Before describing the individual installations of the several manufacturers, it is well to point out the influence which the construction of storage battery cars has had, and is likely to have, on the standard trolley car. The necessity for extreme economy in energy consumption has made the builders of storage battery cars lead in the use of anti-friction bearings for journal boxes and motors, the independent wheel, the metallic-filament lamp, the current-checking meter, and in light-weight trucks and car-body construction. In some cases, as in the attempt to

Table V—Operating Data Frisco Lines, July 1, 1912, to Feb. 28, 1913, for First Six Cars in Table III

Revenue motor car miles	181,438
Revenue trailer car miles	127,605
Per cent of time trailers hauled	70.3
Average working weight of motor cars, tons	51.5
Average load of motor cars, tons (estimated)	3.5
Average working weight of trailer cars, tons	23.5
Average load of trailer cars (estimated), tons	2.5
Average gross weight motor car trains, tons	73.3
Total gross ton miles (revenue only)	13,296,820
Fuel used per motor car train mile, gal. (revenue only)	.751
Gross ton miles per gallon fuel (revenue only)	97.6

	Total Cost for Eight Months	Average Cost per Motor-Car Train Mile
Wages of crews	$14,417.09	$0.0794
Fuel (naphtha)	8,666.42	0.477
Lubrication (gas engine)	1,356.49	0.075
Cleaning, supplies, miscellaneous expenses	1,596.89	0.088
Running repairs, labor	2,908.46	0.160
Running repairs, material	1,242.28	0.067
Total	$30,187.63	$0.1661

Table VI—Operating Data on Fourteen Cars of Frisco Lines, July 1, 1912, to Dec. 31, 1912

Revenue motor car miles	251,627
Revenue trailer car miles	114,164
Total passenger car miles	365,791
Per cent of time trailers hauled	40.3
Fuel (naphtha) used per motor car mile, gal	0.721
Fuel (naphtha) used per car mile, gal	0.496

	Total Cost for Six Months	Average Cost per Motor Car Train Mile
Wages of crew	$19,840.96	$0.0788
Fuel (naphtha)	11,857.68	0.0471
Lubrication (gas engine)	1,553.28	0.0062
Cleaning, supplies and miscellaneous expenses	2,545.91	0.0101
Running and shop repairs	7,769.73	0.0309
Total	$43,567.56	$0.1731

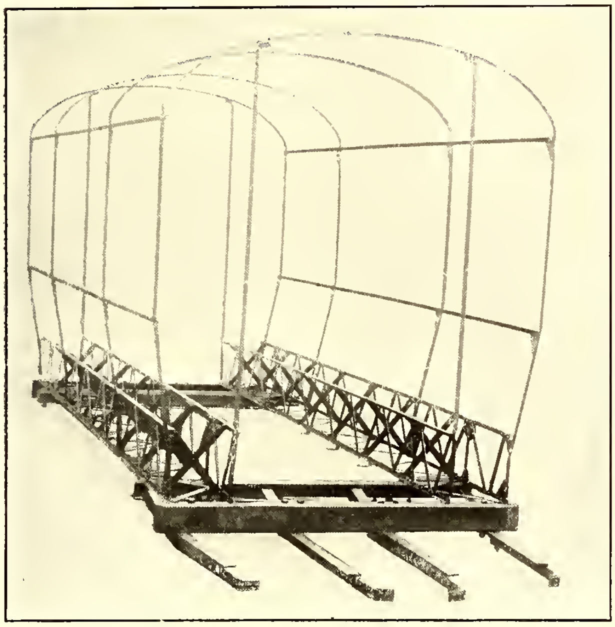
build welded frames, less success has been attained, but, on the whole, the various experiments have been of great value. The small motors used for the services hereinafter described offer the best proof of their success from the standpoint of energy consumption as well as first cost.

TYPICAL INSTALLATIONS OF THE GOULD STORAGE BATTERY COMPANY

The Gould Storage Battery Company has furnished thirty-two 420-amp-hr., fifty-eight-cell equipments to the Third Avenue Railway and has made a number of smaller installations both in this country and abroad.

On Feb. 15, 1913, the Cienfuegos, Palmira & Cruces Electric Railway & Power Company placed in service four cars of the Third Avenue single-truck type. The line is 10 miles long, operating between Cienfuegos and Caonao, Cuba, alongside a highway with a maximum grade of 4 per cent. These cars are 27 ft. 1 in. long over all, with a seating capacity of twenty-eight, although they have carried as many as eighty passengers. The company has since ordered twelve eight-bench, forty-passenger open cars also for storage battery operation.

The Ocean City Passenger Railway Company and the Cape May, Delaware Bay & Sewell's Point Railway, with a total mileage of 7.7 miles, jointly operate two cars, also of Third Avenue design. Two more have been ordered. Since July, 1912, the Cape May cars have been running 80 to 120 miles a day in miscellaneous city service, including even the shunting of freight cars. Current is charged at the rate of 2 cents per kw-hr. The situation at Cape May is unique, for after the consolidation of the lighting and railway interests the use of storage battery cars made it possible to shut down the railway plant except for the few months when the ocean beach business is at its height. During the summer months the storage battery cars are an auxiliary to the ten or

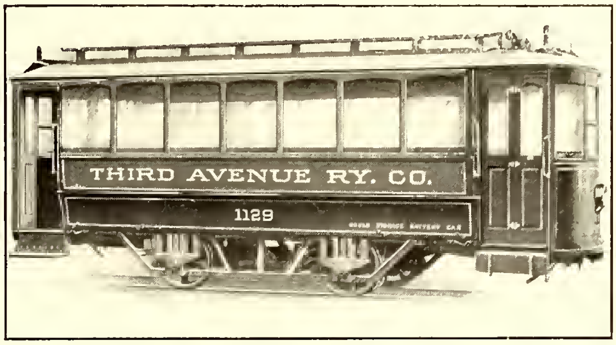


Light Steel Frame for Billings Car with Battery Compartments Used for Side Girders

eleven trolley cars, but in the winter only storage battery cars are employed. These cars are charged for six to seven hours every night from the lighting plant and run about sixteen hours a day. An application of different character is that of the Newbern-Ghent Street Railway, Newbern, N. C., which operates a 5-mile line between the towns named. Three cars are used at present and a fourth is under way. Storage battery cars were adopted here to facilitate real estate development.

This manufacturer has received an order for one car from a South American company, and if it proves satisfactory eight more cars will be ordered. It also expects to close a contract with a West Indian company for six cars. In both instances the cars will be operated in streets which are too narrow for safe overhead construction.

All of the Gould cars have been furnished with antifriction bearings, and the maker believes that for isolated companies with a lack of skilled mechanics the ordinary axle drive is more satisfactory on account of its simplicity than the independent wheel drive of other storage battery cars. The batteries are always designed to do a full day's work on one charge, although boosting is declared to be entirely feasible. All of these cars carry two



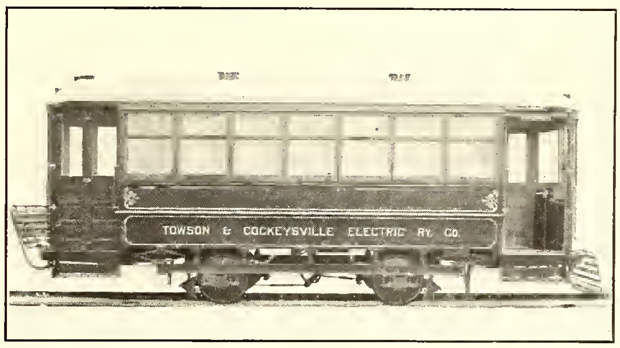
Standard Storage Battery Car, Third Avenue Railway

GE-1022 vehicle-type motors which have a continuous rating of 30 amp at 110 volts and an hourly rating of 75 amp at 110 volts.

TYPICAL INSTALLATIONS OF THE ELECTRIC STORAGE BATTERY COMPANY

The Electric Storage Battery Company has supplied all but thirty-two equipments for the Third Avenue Railway and has filled an order from the New York Railways for forty-five equipments since placed on stepless cars. These battery equipments will be of 420-amp-hr. capacity as on the Third Avenue cars. The Third Avenue Railway, through T. F. Mullaney, chief engineer, under date of June 14, 1913, supplied the data presented in Table VII.

The figures in Table VII do not include any expense for the maintenance of battery, as this feature is cared for by contract with the battery companies, which are paid a definite rate that is less than 3 cents per car mile.

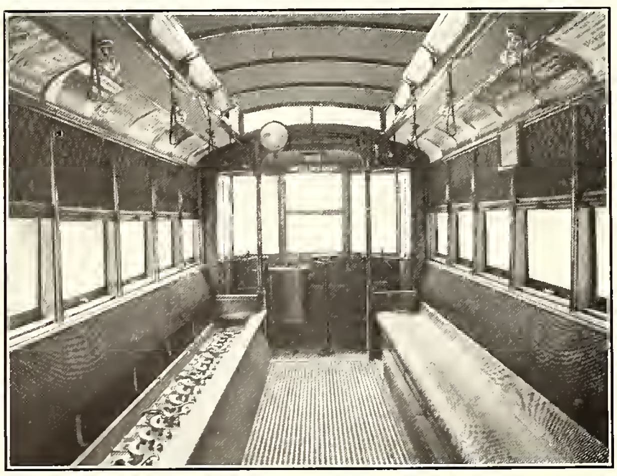


Storage Battery Car with Special Light-Weight Truck

Since Oct. 9, 1912, the Lewisburg, Milton & Watsontown Pasenger Railway Company, Milton, Pa., has used a combination passenger and baggage car which was ordered as an addition to a car from another manufacturer which had been in use since the summer of 1911. This installation presents an interesting example of the increase in traffic which can be obtained on a railroad branch by substituting electricity for steam. Originally this company acquired trackage rights from the Pennsylvania Railroad from Montandon to Lewisburg, a distance of approximately 1½ miles, in order

Storage Battery Car for High-Speed Service

to connect Lewisburg by overhead trolley with Milton and Watsontown. Later the right was acquired to operate on 9 miles of track between Lewisburg and Mifflinburg. A storage battery car was chosen for this extension as the traffic did not justify an overhead line. The cars are operated between steam trains on a schedule published in the Pennsylvania Railroad timetable and their movements are subject to orders from the signal men of the steam road. The later car is 39 ft. 8 in. over all, with a thirty-two-passenger compartment 22 ft. 6 in. long and an 11-ft. 6-in. baggage compartment provided with folding seats for eight smokers. Its total weight is as follows: car body, less electrical equipment, 10,700 lb.; electrical equipment, including battery of nearly 8000



Storage Batteries Under Longitudinal Seats, Third Avenue Railway

lb., 8800 lb.; motors, two GE-1027, 2200 lb.; trucks, 9000 lb.; storage air brakes, 1500 lb.; total, 32,200 lb. The car has a tapering front end to reduce wind resistance, but no anti-friction devices are used except ball-bearing journals. The maximum speed is 30 m.p.h. and the schedule speed is 16 m.p.h. with one to one and one-half stops per mile. The battery equipment consists of eighty-eight cells having a rated capacity of 400 amp-hr. at the six-hour rate of discharge.

Between Oct. 9, 1912, and Sept. 1, 1913, this car ran more than 36,000 miles, making an average of 122 miles a day every day in the week. During this time only 19 miles of schedule operation was lost, and this was on account of the burn-out of a charging plug which incidentally damaged some car wiring. The car is in operation from 5.30 to 8 a.m., running 25 miles, when it is charged until 9.20 a.m. It is in operation again from 9:20 a.m. to 1:30 p.m., running 28.2 miles, when it is charged until 2:30 p.m. It is in operation from 2:30 to 4 p.m., running 18.6 miles, when it is charged until 4:50 p.m. It is in operation from 4:50 to 7:30 p.m., running 25 miles, when it is charged to run from 8:05 to 11:10 p.m., running 25 miles, after which it has the necessary charge to fill up the battery for the first stages of the next day's run. It will be noted that the battery is not large enough for a day's run because the schedule permits longer layover periods, but it is larger than is necessary for a single trip to allow flexibility in rearranging the schedule from time to time. In fact, it is the practice of the company to operate approximately the last 50 miles of the day without any intermediate charging. Charged as at present, the car can make 150 miles a day and even more if desired. An empty battery is charged 30 per cent of its capacity in twenty minutes, 50 per cent in forty minutes, 66 per cent in one hour, to 75 per cent in one hour and twenty minutes and 100 per cent in about three and one-half hours. The characteristics of the battery permit it to receive high-rate charges, when such charging is useful, at approximately 90 per cent amp-hr. efficiency.

The batteries are maintained entirely by the car crews,

Table VII—Operating Data on Storage Battery Cars of the Thiro Avenue Railway, New York

Length of run, minimum	5 miles
Length of run, maximum	10 miles
Length of run, average	8 miles
Maximum grades	5 per cent
Average number of miles per car a day	58
Number of trips per day, minimum	7
Number of trips per day, maximum	18
Number of trips per day, average	10
Maximum speed	15 m.p.h
Schedule speed, minimum	6 m.p.h.
Schedule speed, maximum	7.6 m.p.h
Average number of stops per mile	8
Average duration of stops	6 sec.
Number and type of cars operated (of one type)	121*
Weight of car complete	14,500 lb
Length of car	26 ft. 1½ in.
Seating capacity	26
Number of motors per car, type and rating—two motors, rated 30 amp at 110 volts.	
Kind of battery and number per car, 58-cell, 29-plate lead battery.	
Kw-hr. per car mile used at motors	0.5 to 0.6
Kw-hr. per car mile purchased, a.c. energy at 6600 volts	1 to 1.2
Kw-hr. per car mile battery input	0.910
Amp-hr. per car mile of charge	5.53 to 6.85
Amp-hr. per car mile of discharge	4.52 to 5.45
Amp-hr efficiency of battery	82 per cent
Voltage efficiency of battery	79.1 per cent
Watt-hour efficiency of battery	64.8 per cent
Time required to charge batteries	7½ to 9 hours
Number of miles obtained per charge, normal	85 miles
Number of miles obtained per charge, maximum	119 miles
Operating Cost per Car Mile:	
Platform expenses	8.75 cents
Total repairs to cars, trucks, electrical equipment and all shop and carhouse expense	2.55 cents
Power	1.2 cents

*Now 160 cars.

who required very little instruction. The cost of operation is from 17 to 18 cents per car mile. This total includes a high charge for energy on account of temporary charging conditions. On the whole, this electrification has proved very satisfactory. The Pennsylvania Railroad gets a trackage rental in place of operating an unprofitable train, while the electric railway company also makes money.

EDISON-BEACH INSTALLATIONS

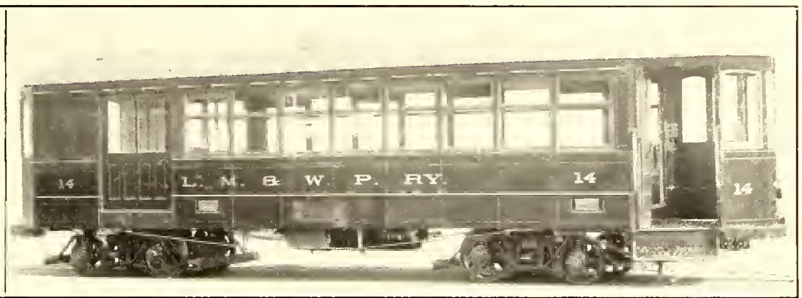
The Federal Storage Battery Car Company has sold some ninety cars in the United States and abroad to about forty-five roads. Characteristics of Edison-Beach installations are operation on very severe grades, use of multiple-unit trains and construction of largest American cars yet produced (52 ft. over-all length).

The traction batteries of this company are rated as follows:

	Type of Cell				
	A-4-H	A-6-H	A-8-H	A-10-H	A-12-H
Rated capacity, amp-hr. output..	150	225	300	375	450
Normal actual output, seven-hour charge, amp-hr.........	168	252	336	420	504
Maximum output on overcharge, amp-hr	190	285	380	475	570
Rated capacity watt-hours per cell	180	270	360	450	540

The Tanana Valley Railway Company, Fairbanks, Alaska, has been operating since the middle of 1912 a single-track combination passenger and baggage car over a 22½-mile narrow-gage line between Fairbanks and Gilmore, this stretch including a 2 per cent grade about 1000 ft. long and 1½ per cent grade about 1 mile long. The daily service of the car comprises two round trips, or 90 miles, with layover boosts of one to one and one-half hours in addition to night charging. The charge for current is the highest known, namely, 20 cents per kw-hr., but without doubt the fares are in proportion. The electrical equipment comprises 135 A-6 cells for traction, five like cells for lighting and four 6.7-hp special type motors. The speed on level track is 25 m.p.h.

The Cambria & Indiana Railway, Colver, Pa., operates a combination baggage and passenger car, 35 ft. 1 in. over all, on a 12-mile three-leg switchback line between Rexis and Colver. This line has a steady rise of 435 ft. in 10 miles and then of 400 ft. in the next 2 miles. On 2 miles a constant grade of 5 per cent prevails. The car makes three round trips a day. On an inspection trip when there was 2 in. of snow on the ground only 212 amp-hr. was required for a 24-mile run, the time of the round trip being two hours and five minutes. Upon this the battery was boosted for forty-five minutes, and the following round trip, which was made in one hour and forty-four minutes, required 178 amp-hr. The battery was then boosted for one and one-half hours, the third trip requiring one hour and forty-eight minutes with an energy consumption of 162 amp-hr. The battery finally had the usual seven-hour night charge before going into service the next day. During the run five intermediate stops were made each way. The average loaded weight of the car was 18 tons. The energy consumption worked out at 7.66 amp-hr. per car mile or 64 watt-hr. per ton mile. The equipment of the car consisted of 130 A-10 cells for traction, five like cells for lighting and four 10-hp motors.



Typical Storage Battery Cars for City and Light Interurban Service

As to grades, the Burlingame (Cal) Electric Railway has used one single-truck car, 27 ft. 6 in. over all, since the spring of 1913 on a suburban run about 7000 ft. long. This short run, however, has a grade of 5.2 per cent for 250 ft., followed by somewhat shorter lengths of 2.4 per cent and 3.4 per cent and then by 250 ft. of 12.76 per cent grade. The calculated speed of this car is 23 m.p.h. on the level and 5 m.p.h. on the maximum grade mentioned. This extraordinary service is handled by four 10-hp motors and 119 A-10-H traction cells. Five cells of the same type are used for lighting. The battery equipment is boosted for three hours and forty-eight minutes during the day in addition to the usual seven-hour night charge. The railway buys energy from the local lighting company at 2½ cents per kw-hr. for the first 5400 kw-hr. taken in a month and 1½ cents for the second 5400 kw-hr.

Two cars with 18-ft. bodies are used by the Manhattan Beach Estates, a high-grade realty development at Manhattan Beach, New York. These cars are operated through the estates on a track less than 1 mile long to furnish connection with the station of the Long Island Railroad Company. The electrical equipment of each car includes ninety-five A-6-H cells for traction, five like cells for lighting and two 10-hp motors.

STORAGE BATTERY TRAIN FOR HAVANA

The Electric Railway Journal for Sept. 28, 1912, contained an article on the three-car multiple-unit battery train built for the United Railways of Havana. The service was begun on Jan. 8, 1913. Owing to the tropical climate, bad track conditions and too high a gear ratio trouble was experienced at once from the excessive heating of the batteries, but these difficulties were readily corrected by an increase in the number of cells and a reduction of the gear ratio. The following account is an abstract of a report on this installation as made to R. M. Orr, general manager, by John A. Thompson, electrical engineer of the company:

The cars are of the double-truck type, seating forty passengers each. The trucks, which are among the best features of the car, are of diamond-frame pattern with fixed axles and revolving wheels. The wheels rotate on roller bearings and the end thrust is taken up by ball-bearing thrust plates. The friction is very low, and grinding of wheels and rails on curves is eliminated. The smooth-running qualities of these trucks are very noticeable. The air-brake equipment has been changed from the storage air system to standard straight and automatic system with a motor-compressor mounted on the cars and operated from the battery.

The batteries are Edison A/6 type and have a rated capacity of 225 amp-hr. Originally there were 220 cells per car, 200 for power and twenty for lighting and control circuits; but these have been increased to 239—228 for power and eleven for lighting and control. The seven hours. The original mileage on one charge was 65 miles, but this has been increased to 75 miles.

The only attention required by the battery is the addition of distilled water. This can be attended to by the operator in charge of the charging station at any time while the car is lying over for charging. Two boys earning $1.50 per day and a car cleaner at $1 a day are the only attendants in addition to the train crews who are required to run the cars.

On Jan. 8, 1913, regular service was begun on the old United Railway main line between Cienaga and Galiano. The schedule advertised was a train each way every fifteen minutes, passing at Pueblo Nueno station. The round trip was 6.6 miles, with fourteen stops per round trip. The schedule time was thirty minutes, so that there were always two cars on the line while the other was lying over at Cienaga charging station. The method attempted was to send each car out for one round trip taking thirty minutes, then to charge it for fifteen minutes, then to send it out again for another round trip and so on.

Difficulties began at once. The schedule could not be

Table VIII—Operation of Storage Battery Cars Between Cienaga and Galiano, Cuba, After Gear Ratio Had Been Changed and Number of Cells Increased

Date	Car Miles	Fares	Fares per Car Mile	Kw-hr. from Trolley	Kw-hr. Lost in Resistance	Kw-hr. to Battery	Charging Efficiency	Kw-hr. per Car Mile			Cost of Cur'nt		Wages		Total Expense	
								From Trolley	To Battery	To Motors	Dollars per Day	Cents per Car Mile	Dollars per Day	Cents per Car Mile	Dollars per Day	Cents per Car Mile
March 5.	330	...	...	855	273	582	68.1	2.60	1.77	0.745	34.20	10.4	29.00	8.8	63.20	19.2
March 6.	455	...	...	997	293	704	70.6	2.20	1.54	0.722	39.88	8.8	29.00	6.4	68.88	15.2
March 7.	...	...	...	93	32	61	65.6	...	...	...	3.72	...	...	...	Lying	over
March 8.	436	866	1.99	1120	330	790	70.6	2.57	1.81	0.774	44.80	10.3	29.00	6.7	73.80	17.0
March 9.	462	1532	3.31	1200	355	845	70.4	2.60	1.83	0.771	48.00	10.4	29.00	6.3	77.00	16.7
March 10	462	701	1.52	1128	338	790	70.0	2.45	1.71	0.743	45.12	9.8	29.00	6.3	74.12	16.1
March 11	449	728	1.63	1082	342	740	68.4	2.41	1.65	0.823	43.28	9.6	29.00	6.5	72.28	16.1
March 12	462	746	1.62	1028	312	716	69.7	2.23	1.55	0.788	41.12	8.9	29.00	6.3	70.12	15.2

Remarks: March 5 to 6—No passengers. From March 8 to 12—Regular service.
Kw-hr. per car mile from trolley and to battery are correct. Kw-hr. per car mile to motors are only approximate.

Round trip, miles	6.6	Average kw-hr. per car mile to battery	1.72
Number of stops per trip	14	Average kw-hr. per car mile to motors	0.76
Schedule time, minutes	27	Average cost per car mile for current at 4 cents	9.84
Schedule speed, m.p.h	14.7	Average cost per car mile wages, cents	6.64
Average kw-hr. per car mile from trolley line	2.46	Average cost per car mile total, cents	16.48

four motors are each rated at 10 hp, 200 volts, 37.5 amp, 800 r.p.m., and are guaranteed to stand an overload of 100 per cent for short periods. The motors are geared to the hub of the driving wheels through single reduction wheel and pinion gearing. The gear ratio was originally 26:68, but it has been changed to 15:79. The system of multiple-unit control works very satisfactorily.

Each car is fitted with a two-point receptacle for receiving the current and a connection for an ordinary air coupling for charging the air tank. The car is switched up alongside the charging station and the connections are made in less than a minute. The rate of charging is varied by cutting out the series resistance. The amount of current that can be put in during a certain time is limited by the heating of the cells. The allowable rates given by the makers are: Five minutes at 225 amp, twenty minutes at 180 amp, thirty minutes at 135 amp, sixty minutes at 90 amp and normal rate, 45 amp for maintained; the batteries heated to 140 deg. Fahr., causing discomfort to passengers; the motors heated and the batteries lost their charge because it was impossible to put enough charge into them during the layover. An attempt was made to relieve matters by altering the schedule to every half-hour from 10:09 a.m. till 4:09 p.m. This also proved unsatisfactory, and the cars were withdrawn from service on Jan. 15 with two motors burned out.

The causes of this failure were several. The track was very bad within city limits and it was completely covered with dust in some parts. As the gear ratio was too high for such frequent stops, it caused an abnormal current discharge, heating up both batteries and motors and pulling down the voltage. Owing to the frequent stops the equipment had no chance of cooling down again. From the same cause also the energy used per car mile was excessive so that the car had to be charged at a high rate during the layover to make up for it. This also kept up the temperature of the batteries. Then, finally, owing to the inconvenient tracks at Cienaga, time was lost in switching, so that the charging did not amount to more than seven to ten minutes.

The ampere-hours used per round trip averaged about 35. With an ampere-hour efficiency of 85 per cent this amounts to 41.2 amp-hr. on charge. To keep up the fifteen-minute schedule all day would require that at least 30 amp-hr. be put into the battery after each run. The average time being say ten minutes or one-sixth hour, the required current would be at least 180 amp. According to the makers' figures, 180 amp can be put into the battery for twenty minutes; but this is on the assumption that it is cool to begin with. In this case the cells were hot from an excessive discharge and were kept hot by excessive charging rates.

It was decided to reduce the gear ratio and enlarge the power battery as already noted. The effect of these changes was to reduce the current discharge in starting and accelerating, to raise the average voltage on discharge, to reduce the kilowatt-hours per car mile and to raise the charging voltage nearer to that of the line so as to have less waste in the charging resistance.

Multiple-Unit Cars with Continental Type Suspension, Used Singly for Passenger Service and Together as a Freight Locomotive

On March 5 the alterations were completed on all three cars, and they were tried out on the Cienaga-Galiano run without passengers. They were found to be able to keep up a fifteen-minute schedule all day, so they were put in regular service again on March 8. The operating records up till March 12 are given in Table VIII. The batteries still heat up to about 116 deg. Fahr. after a heavy run, but this is hardly noticeable to the passengers.

The kilowatt-hours per car mile for March 12 are as follows: 2.23 from the line, 1.55 to the battery and 0.788 to the motors, or 0.0394 per ton mile. The charging efficiency is 69.7 per cent and the battery efficiency 50.8 per cent. Each car now makes five consecutive runs without recharging and is then put on charge for an hour and a quarter. This method is a decided improvement and saves time in switching.

In conclusion Mr. Orr says that the cars now come up to guarantee with regard to energy consumption. The consumption of 39.4 watt-hr. per ton mile is extremely low and is due to the special type of truck with fixed axle and roller bearings. The efficiency of the battery is only 44.4 per cent, and this is an inherent defect in the Edison battery. Better efficiencies than this may be had under special circumstances, but it is doubtful if it has ever been much above 50 per cent in car service. Taking the figures for March 12 as before, 0.79 kw-hr. per car mile is used in the motors and 0.76 kw-hr. per car mile is lost in the battery. Even at 4 cents per kw-hr., this represents a charge of 3.04 cents per car mile. If a lead battery was used, the cost of upkeep would be more than 3 cents per car mile; therefore no matter what the efficiency of the lead battery might be it is bound to be more expensive to operate than the Edison battery, even with current at the high price of 4 cents.

OTHER INSTALLATIONS WITH EDISON BATTERIES

The first steam line to which the storage battery car was applied was the 2.3-mile Bushwick branch of the Long Island Railroad. On April 1, 1911, it was furnished with one 28-ft. car equipped with two 15-hp motors. Up to April 1, 1913, this car ran more than 60,000 miles. The railroad company reports that the car saves $21 a day as compared with a steam locomotive and coach. This is equivalent to a saving of more than $14,000 for the first twenty-three months of operation, while the car itself cost $6,000. Table IX is a

Table IX—Operation of Bushwick Junction Branch, Long Island Railroad

Length of run, miles	2.3
Number of grades	2
Maximum grade, per cent	0.7
Average number of miles per car per day	45
Number of trips a day	9
Maximum speed, m.p.h	20
Schedule speed, m.p.h	15
Average number of stops per mile	1.2
Average duration of stops, minutes	4
Weight of car complete, lb	16,000
Length of car, ft	28
Seating capacity	26
No. of motors per car, type and rating—two series, 15 hp each	
Kind of battery and number of cells per car	125 A-4
Kw-hr. per car mile purchased power	2.86
Time required to charge batteries	2 hr. 30 min.
Number of miles obtained per charge	45

report on the operation of the Bushwick branch as made under date of June 11, 1913, by George Gibbs, chief engineer electric traction Long Island Railroad Company.

The batteries are charged through a line about 3 miles long, receiving 675-volt current from the third-rail. The size of the wire is so proportioned that the necessary resistance is obtained for full charges. Under this condition the kilowatt-hours per mile are very high, as the company prefers to waste some energy in line losses rather than to use a motor-generator set of proper voltage and provide an attendant for operating.

The Long Island Railroad Company also has operated since May 26, 1913, a 32-ft. car on a 7½-mile branch between Valley Stream and Mineola. It seats thirty-two persons and weighs about 22,900 lb. light. The schedule calls for six intermediate stops and is made in twenty-two minutes. The car is capable of a maximum speed of 33 m.p.h. It makes seven round trips a day and one round trip from Valley Stream to Rockaway for the night layover, making a total of 115 miles a day. The battery is boosted during the seven layovers of the day, which vary from fourteen minutes to two hours and twenty-seven minutes. The electrical equipment consists of 213 A-4 cells for traction, five similar cells for lighting and four 10-hp motors.

The Billings (Mont.) Traction Company operates five cars, each carrying 105 A-6 cells for traction, five like cells for lighting and two 10-hp motors. The traction company buys energy from the lighting company at 2 cents per kw-hr. and refrains from charging during the lighting company's peak loads.

The Wilmington (Del.), New Castle & Delaware City Traction Company was originally a 10-mile overhead line. The cars were sold and operation discontinued for three years, after which the overhead system was taken down and sold and a 32-ft. car of Continental type installed Nov. 1, 1911. This car was equipped with 205 A-4 cells for traction, five A-4 cells for lighting and four 12½-hp motors. Although the road had 7 per cent grades and poor track, this car was able to haul a freight trailer weighing from 7 tons to 10 tons. Since this installation the company ordered two double-truck cars, the first in September, 1912, and the second during the current year. These are of the combination baggage and passenger type, one car carrying 225 A-6 cells for traction, five similar cells for lighting and the other a similar combination of 225 A-6 H cells. Both cars have four 12½-hp motors. The 9½ miles between Dobbinsville and Delaware City, including a 6 per cent grade over a drawbridge and a 7 per cent grade at an overhead railroad crossing, is made in thirty minutes, although the run can be made in fifteen minutes. The stops are favorably located on the tops of grades so that cars frequently coast half way to the next station. A typical operation is to have the car run for thirty-five minutes and to lie over at Dobbinsville for fifty minutes. When two cars are used the full hour schedule is maintained, the distance being made in thirty minutes each way, with one hour for layover and charging available at Dobbinsville for each trip.

Storage Battery Stepless Car, New York Railways

Early in the summer of 1913 the Twin Falls (Idaho) Railway placed in service a two-car multiple-unit train consisting of 38-ft. combination passenger and baggage cars, the bodies mounted on trucks of 19-ft. wheelbase. The cars are operated either singly or in pairs for passenger service and in pairs for hauling freight cars at night. Each one is equipped with 190 A-6-H cells for traction, twelve like cells for control and lighting and four 10-hp motors, multiple-unit equipment, air brakes, etc. The cars are now operated on a line which is only 3 miles long, but the full service will cover a 12-mile line between Twin Falls and Shoshone Falls. The territory served is a rich farming country requiring railway service but not populated enough to call for standard electric railway operation.

The Chesapeake & Ohio Railway purchased a year ago a 38-ft. car for operation on a 12-mile branch between Covington & Silver Grove, Ky. This car weighs 34,000 lb. and is geared for a maximum speed of 39 m.p.h. The car is not now in operation in view of the fact that the railroad wanted it to take the place of two steam trains. The schedule was too severe to permit this end to be accomplished regularly because blockades by freight trains did not permit the minimum of thirty minutes' layover time at the end of each round trip as required for boosting. The operating records show that the car ran as many as 264 miles in one day, but, of course, this performance could not be kept up continuously.

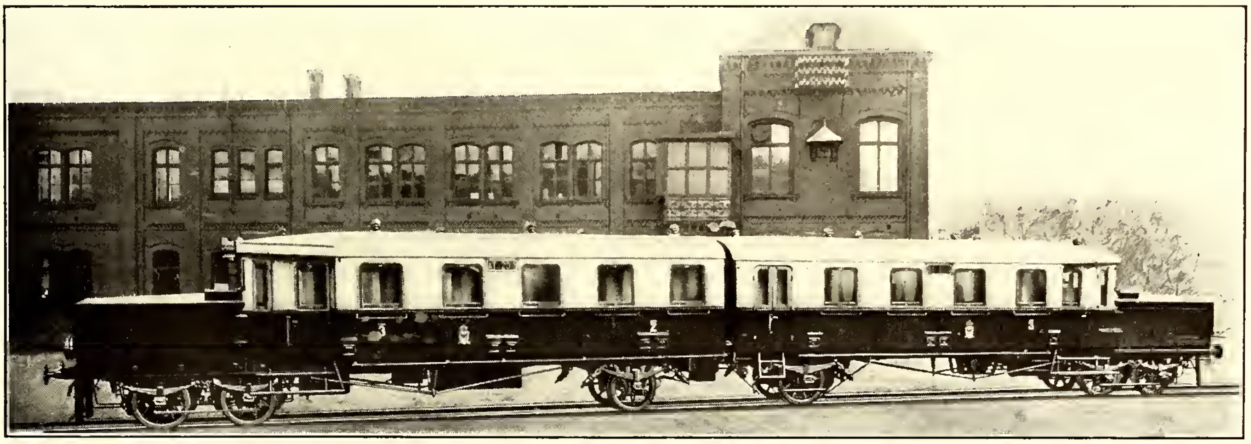
The Lorain (Ohio), Ashland & Southern Railway operates a combination passenger, baggage and smoking car, 50 ft. over all, equipped with 220 A-8-H cells for traction, seven similar cells for lighting and four 20-hp motors. A test of this car was made on the tracks of the Jamestown (N. Y.), Chautauqua & Lake Erie Railway, as a result of which the Jamestown company has ordered a car of simliar design.

The St. Joseph Valley Railway, Elkhart, Ind., placed in service early in the summer of 1913 a 50-ft. combination car weighing without load 61,750 lb. and equipped with 224 A-10-H cells for traction, six similar cells for lighting and four 30-hp motors. In a test on the Erie tracks with a total load of 31.77 tons this car made an average speed of 37.8 m.p.h. on level track and consumed 106 kw-hr. per car mile, or 33.4 watt-hr. per ton mile, for a run of 31.1 miles, which included eleven intermediate stops and a 7-mile continuous grade of 1½ per cent. The car is geared for a maximum speed of 40 m.p.h.

STORAGE BATTERY AND OTHER SELF-PROPELLED CARS IN GERMANY

A remarkable feature of German storage battery practice is the fact that its development has been confined practically to steam railroads, of which the installation on the Prussian-Hessian State Railroads is by far the largest. The leading thought in creating this self-propelled car traffic was not to obtain a saving in operating costs but to improve the means of travel on lines which hitherto had had very poor service. The results have proved very satisfactory to the public and the railway administration.

In most cases the routes are weak traffic lines, radiating from cities where cheap current is available. In 1906, when the service was begun, experiments were made also with steam cars and gas-electric cars, but it was found that the former were not satisfactory and that the latter had not yet reached the desired degree of reliability. As of June 1, 1913, there were in service throughout Germany 148 accumulator cars, ten gas-electric cars and five steam cars, costing a total of $2,795,000. There were also under construction forty-three accumulator cars, six gas-electric and two Diesel-electric motor cars, so that at the end of 1913 a total of 200 motor cars will be in use. The 152 cars in service during the first part of 1913 operated on 180 sections with a total length of 3070 miles. The lengths of run on one charge are as follows: 125 cars, 62 miles; twenty-seven cars, 81 miles; nineteen cars, 112 miles, and five cars, 56 miles. The total approximate mileage of self-propelled cars has grown as follows: 1907, 124,000 miles; 1908, 357,000 miles; 1909, 1,520,000 miles; 1910, 1,860,000 miles; 1911, 2,726,000 miles; 1912, 3,720,000 miles, with an estimate of 4,960,000 car miles when the new cars are included. The mileage of routes will also rise to 3600 miles. Energy for the accumulator cars is supplied from fifty-three charging stations.



Twin Storage Battery Car, Prussian State Railways

The cars are operated in accordance with the standard steam railroad regulations. These regulations do not forbid the operation of motor cars by one man, but two men are employed for the sake of safety, although it is appreciated that automatic devices, such as the dead-man's handle, are available for one-man service. The wages of the motor-car operators are less than those of locomotive engineers, owing to the short period of instruction required to handle the car and make minor repairs. The conductors receive the training of motormen and are their logical sucessors. The conductors or trackmen must have one year's training, four months of which is used in acting as motormen under an instructor. The steam and gas-electric cars, on account of their greater complexity, are operated by locomotive engineers.

Trailers are rarely used, nor is any attempt made to operate trains of accumulator cars, although multiple-unit apparatus is available for that purpose. All of the accumulator cars have been furnished by one company, the Accumulatoren Fabrik Aktiengesellschaft, which undertakes for 3.4 cents per car mile (with a small extra guarantee if the minimum distances of 62,000, 80,600 or 111,600 miles for the three different types of cars shown in Table X are not made before the replacement of the positive plates) the entire maintenance of the batteries, including replacement of plates and electrolyte. For this service one man may attend to a maximum of four stations and ten cars. In case of extensive repairs the railways furnish labor without charge. The railways also furnish free transportation for men and battery material and make all arrangements for charging plant buildings and supply of current. The battery company, however, is responsible for the reliability of service.

Table X—Standard Accumulator Cars of the Prussian-Hessian State Railways

Run on one charge	62 miles	80.6 miles	112 miles
Design	Two short-coupled 3-axle coaches		
Carrying capacity	100 persons in third and fourth classes		
Approximate weight (empty) (metric tons)	58.5	60	66
Maximum speed	About 37.2 m.p.h.		
Approximate price without battery and without electrical fittings	$7,500	$7,750	......
Motor equipment	Two 85-hp capacity one-hour rating		
Approximate weight of electrical fittings	8 tons		
Approximate price of electrical fittings	$5,750		
Number of cells	168		
Type of cells	V-GC-185	VI-GC-185	VI-GC-235
Capacity on two hours' discharge, amp-hr	368	443	562
Approximate mean discharge voltage	300		
Charging voltage	340-460		
Approximate weight of battery, tons	18.5	20	25.5
Approximate price of battery	$5,500	$6,000	$7,50
Approximate price of complete coach	$18,640	$19,600	$21,360

OPERATING COSTS OF PRUSSIAN CARS

Tables X and XI are based on a performance of 2,366,000 car miles from April 1, 1911, to March 31, 1912, of which 2,287,000 car miles were operated by means of storage battery cars with series-wound motors, the remainder being made by one storage battery car with shunt-wound motors, four steam cars and four gas-electric cars.

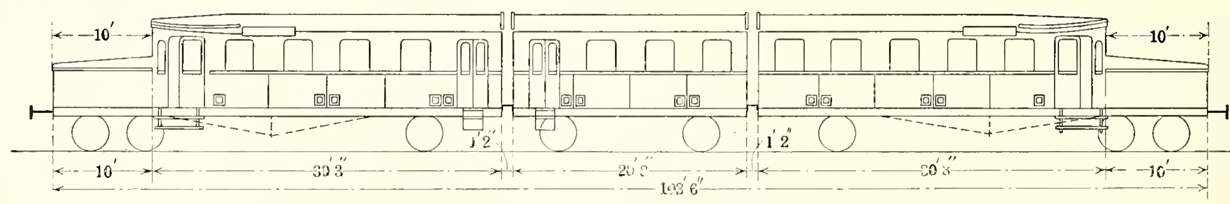
Table XI—General Data on Prussian Cars

	Average	Highest	Lowest
Annual performance, miles	25,532	39,637	16,058
Number of passengers per trip	27.4	55	15.3
Operating time, per cent	....	77.8	....
Reserve time, per cent	....	9.0	....
Shop time, per cent	....	13.2	....
Earnings per car mile, cents	24.6	57.6	15.1
Expenses per car mile, cents	20.8	33.1	15.2

Although the early experiments with shunt-wound equipments for regenerative control were not satisfactory, five simplified equipments were built during 1912. Four of these cars have but one motor on account of the difficulty of operating shunt-wound motors in parallel. The speed regulation of the one-motor cars is obtained by parallel-series connection of the battery halves in addition to the usual resistances. Experiments indicate that these equipments are not so economical as the series motors if the longer grades are less than 1.7 per cent. The operating expense of the four gas-electric sets was 19.28 cents per car mile. The latter cars are wanted for high speeds like 44 m.p.h., but they have not yet been developed to the desired degree of reliability. Tests of three storage battery cars equipped with roller and ball bearings appear to show that they are more advantageous for service approximating street car conditions, and that in any event their economy would not justify the conversion of cars with ordinary bearings.

Table XII—Division of Expenses of Prussian Cars

	General, Cents per Car Mile	Average per Cent of Earnings	Highest, Cents per Car Mile	Lowest, Cents per Car Mile
Fixed charges on investment (4 per cent) and depreciation of cars and charging plants	5.52	26.60	12.00	3.44
Current	5.24	25.15	10.08	2.00
Heating	0.44	2.10	0.80	0.16
Employees	4.20	20.25	6.80	2.76
Lubrication, cleaning, station attendance, etc.	0.74	3.55	1.76	0.8
Maintenance of batteries, including amortization	3.84	18.4	5.26	3.56
Maintenance of car equipment exclusive of batteries	0.82	3.95	2.20	.08
Total	20.80	100.00		



Articulated Storage Battery Car of Triplet Type for Prussian State Railways

The State Railways are now working in two directions—increasing the running range and improving the conveniences of the cars. As previously noted, nineteen cars have been equipped for a range of 112 miles and it is proposed to build a six-axle twin car for a range of 186 miles. The State Railways have also built several triplet cars, namely, twin passenger cars with an intermediate baggage body. These are mounted on eight axles and are about 125 ft. long. The straight passenger design seats 187 passengers. The characteristics of the 168-volt battery sets are given in Table XIII.

Table XIII—Characteristics of German Battery

Range in car miles	62	80.6	111.6
Capacity on two-hour discharge basis, amp-hr	368	443	562
Maximum charging current, amp	200	240	300
Normal charging current, amp	160	192	240
Charging time with maximum charging current and complete discharge, hours	2	2	2
Charging time with normal charging current and complete discharge, hours	2½	2½	2½