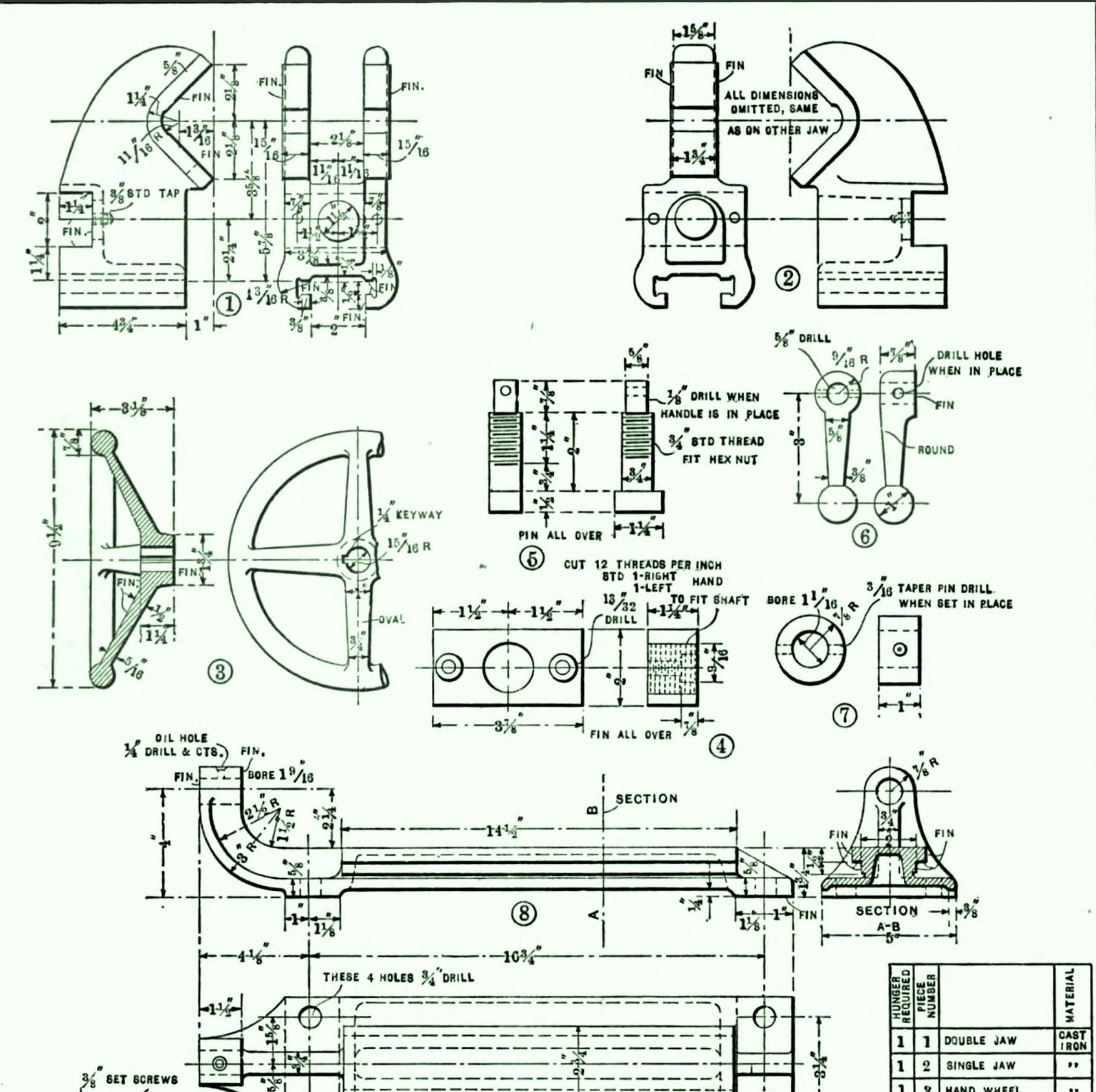

Electric car maintenance

Walter Jackson

ELECTRIC CAR MAINTENANCE

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SELECTED FROM THE ELECTRIC RAILWAY JOURNAL

BY

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PREFACE

The articles on "Electric Car Maintenance" have been selected from the columns of the Electric Railway Journal exclusively except that some braking and wiring diagrams were added in order to secure a more extensive series of shop instruction prints. It is believed that this work should find ready acceptance among those who are in charge of the maintenance of electric railway cars because it places in such convenient form a great deal of useful data which hitherto had been lost to most shopmen within a few months after the original publication in periodical form. As a rule, the methods described are such as require no costly apparatus and of a kind which can be applied to a great many situations. Unlike a text-book, a shop practice compilation of this kind remains up to date as long as the equipment described is in use, and even longer, since many of the labor-saving methods are applicable to any form of car equipment.

W. J.

NEW YORK,
February, 1914.

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CHAPTER XIV

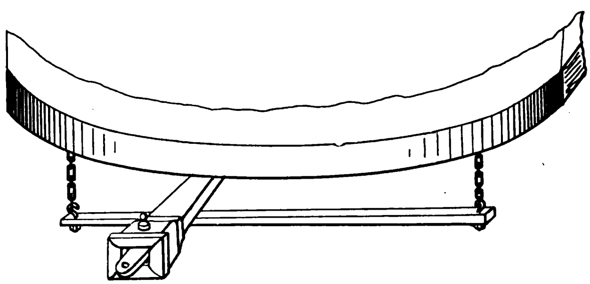
ELECTRIC CAR MAINTENANCE METHODS

I

MECHANICAL APPLIANCES FOR TRAIN OPERATION

Carrying Air Connections in Denver.—On the Denver & Interurban Railway the air connections between the motor car and trailer are carried up on the dash several feet above the bumper instead of being under the bumper. This is claimed to have two advantages. One is that it is easier to couple up the connections when they are in plain sight in this way. The other is that the hose is out of the dirt and is not so much subject to wear.

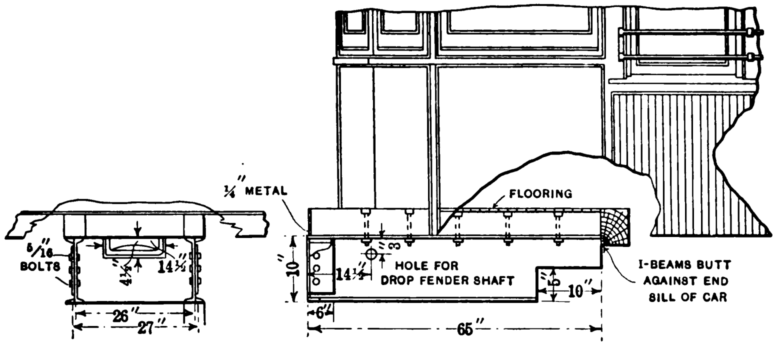
Chain Carry-iron for Draw-bars.—The Little Rock (Ark.) Railway & Electric Company uses the improved form of draw-bar carry-iron on its



Chain carry-iron for draw-bars, Little Rock, Ark.

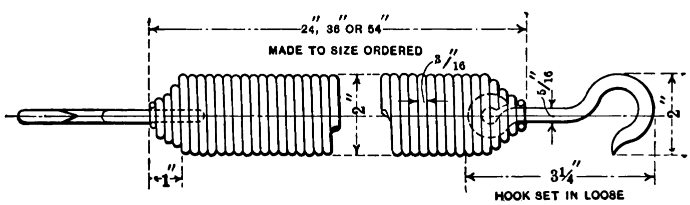
trailers, shown herewith. This consists simply of a pair of chains so that in rounding curves the draw-bar carry-iron is allowed to swing. Thus the amplitude of the coupler arc is increased and the derailment or damage of trailers on sharp curves is prevented.

Special Bumpers to Prevent Overriding.—In 1909 safety bumpers were added to all of the high suburban cars of the Detroit United Railway. The additional bumpers have a depth of 10 in. and will prevent overriding if the suburban cars come in contact with city cars having low platforms. An accompanying illustration presents a side sectional view of the floor of a car with the safety bumper installed. At each end of the car two 10-in. I-beams 5 ft. 5 in. long are bolted to wooden sills and are butted against the end sills of the car. The I-beams are held vertically and are spaced 26 in. apart between centers. At the bumping end they are blocked apart and are sheathed on the outside with metal ¼ in. thick.



Non-climbing bumper for suburban cars of Detroit United Railway.

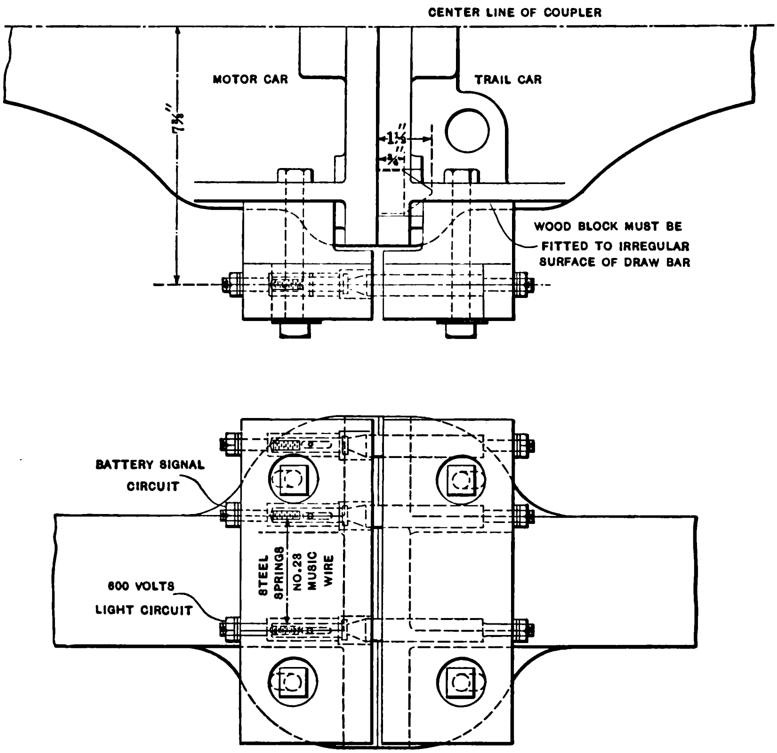
Inter-dashboard Spring.—The accompanying drawing shows a spring which is installed between the dashboards of cars of the International Railway, Buffalo, N. Y., to prevent passengers from getting in between cars that are operated in trains. The spring is wound up from 3/16-in. steel wire, and the ends are coned to form a socket for the eyes of the hooks. This arrangement produces a simple and effective swivel connection between the hooks and the spring. The springs are made of such lengths as to bring them nearly taut in the normal position of the cars.



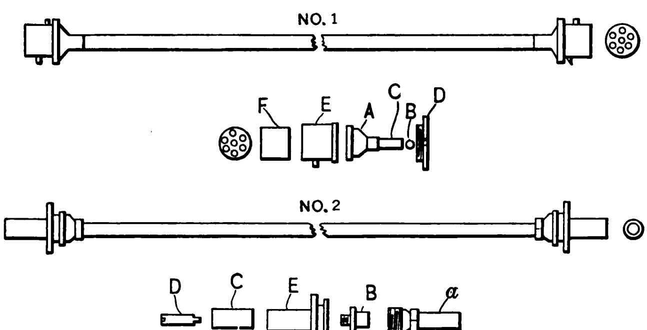
Springs for train platforms in Buffalo.

Coupler with Signal and Lighting Attachments.—In equipping its new trailers the United Railways of St. Louis has greatly simplified the coupling of motor and trail cars by some home-made additions to the standard form of Tomlinson coupler. As shown in the upper drawing on page 3, the coupler has been provided with two wooden blocks carrying three spring contacts. Two of these contacts are used for the signal circuit and one for the lighting circuits. Thus at one operation the coupler couples the cars, air, lights and signals.

Train Cables Covered with Rubber Hose (By George M. Coleman).—The lower illustration on this page shows a train cable and bus line jump-



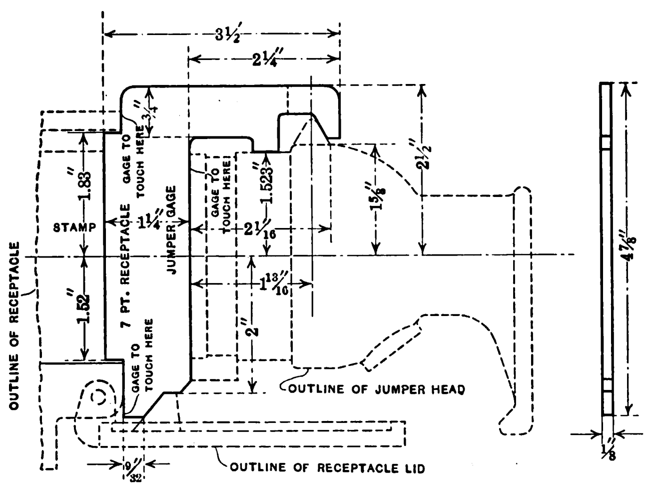
St. Louis coupler with signal and lighting connections.



Cable and bus line jumpers for train cables covered with rubber hose.

ers for connecting two Sprague General Electric multiple-unit cars. By using a covering of rubber hose the jumper is made absolutely moisture-proof, the cable is kept from wearing out and good insulation is insured. This hose can be easily replaced when worn out.

Sketch No. 1 shows the train cable jumper complete. After the hose is cut to the proper length it is fitted with threaded collars (*D*), the threads being placed toward the outer edge. The couplers (*C*) are painted and forced on the ends of the hose, after which small screw contacts are soldered on the end of the cable and assembled in the insulated block (*F*). The cable is then drawn through the hose and pulled out far enough to solder on the small screw contacts. After this an iron clamp is clamped on the hose to keep the cable from slipping back into it. The contacts are assembled in the other block (*F*) and the threaded collar (*D*) is screwed into place on each end.

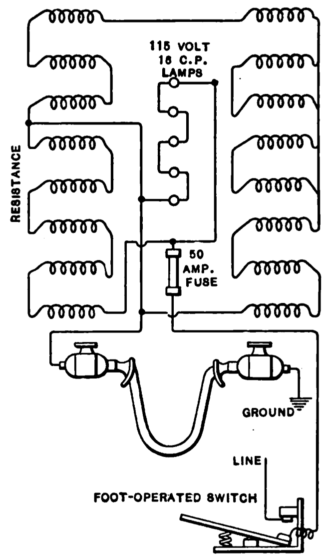


Seven-point jumper and receptacle gage, Brooklyn.

Sketch No. 2 represents the bus line jumper complete. After the hose is cut to the proper length the couplers (*A*) are painted and forced on the hose. The small terminal (*B*) is soldered on one end of the cable. The terminal is inserted in the insulated block (*C*) and the contact (*D*) screwed into place. The cable is drawn through the hose and clamped, then the other end is assembled and the collar (*E*) is screwed into place, making the entire outfit moisture-proof.

Jumper Testing in Brooklyn.—The shops of the Brooklyn Rapid Transit System where elevated equipment is maintained are equipped with seven-point jumper testing outfits as illustrated. The test part is fitted with jumper receptacles and with sixteen 5-ohm coils so wired that a current of 50 amp. will pass in series through all of the wires of the test jumpers. As the normal service current which passes through these jumpers is not more than 2 amp. to 3 amp., a trial with 50 amp. results in burning out any weak connections such as are due to the abrasion of wire or similar causes. A fuse is installed to limit the testing current to 50 amp. There is also a lighting circuit of five 115-volt, 16-c.p. lamps to indicate that the jumper circuit is closed. If the lamps light up but go out immediately, the operator knows that the connection has been

	MATERIAL REQUIRED FOR TESTING SETS
NO. REQ'D	DESCRIPTION
2	WEST. 7 POINT RECEPTACLES
16	CONSOL. NO. 93 HEATERS-5 OHM COILS
5	115 VOLT-16 C.P. LAMPS
1	"NOARK" FUSE-50 AMP.-500 VOLTS
1	FUSE BLOCK FOR "NOARK" FUSE-30 TO 50 AMP.
40 FT.	NO. 6 WIRE - T.D.-6-2



Wiring diagram of board for train line jumper tests, Brooklyn.

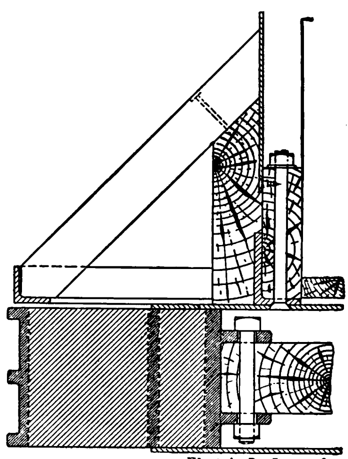
burned out. This test board also carries a jumper and receptacle gage, of the design shown in the drawing, to make certain that good train-line connections will be secured without having recourse to a hammer or other violent means. The inspection of jumpers is made once a month upon which occasion a streak of red or green paint is applied to indicate the month when the test was made.

II

NON-ELECTRICAL PARTS OF THE CARBODY

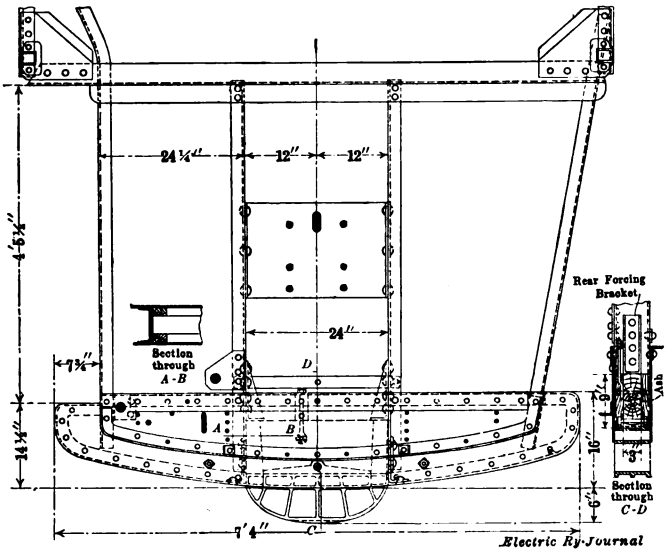
Wrapping Rusty Hand Rails.—In many sections of the country where the humidity is comparatively high considerable difficulty is experienced in eliminating damage to clothing from rust accumulation on the hand rails. This difficulty is experienced particularly in Texas and has been overcome by the application of linen tape coated with shellac on portions of the hand rails in the vestibules of the prepayment cars. Those portions of the hand rails and stanchions which might come in contact with the passengers' clothing are wrapped with one layer of linen tape and receive three coats of shellac. After a comparatively short period in service, the surface of the paint wears as smooth as the iron rail, and there is no tendency for it to ravel.

Wood-cushioned Bumpers for Steel Cars.—The Montreal Street Railway has found that a disadvantageous feature of steel cars, as ordi-



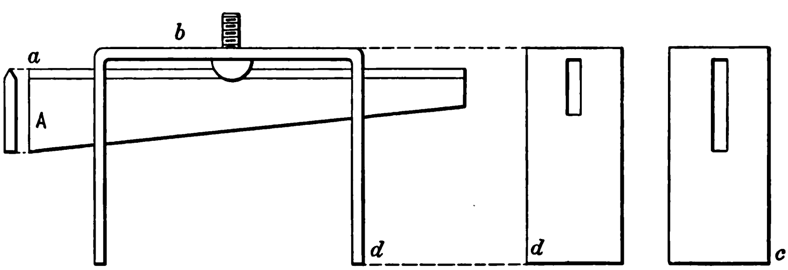
Wooden buffer block, Montreal.

narily constructed, is the tendency toward the loosening of rivets and buckling of members under impacts which, within certain limits, would be readily absorbed by a wooden car. The shock of steel against steel at only 2 m.p.h. was enough to produce serious damage. To avoid trouble from this source in the future, the continuous bumper channel has been superseded by the construction illustrated in which a central box girder with a cushion block of ash is used. This construction has been found capable of absorbing impacts of 5 m.p.h. without starting a rivet.



Wood-backed buffer for steel-frame street car, Montreal.

To Hold Machine Screws.—It is often necessary to run the thread further down on machine screws, to cut them shorter, or to file them to a point. To hold them between the jaws of a vise spoils the head and will not hold the screw firmly. The jig shown in the accompanying cut is very simple and easily made, and will hold any screw with a slot.

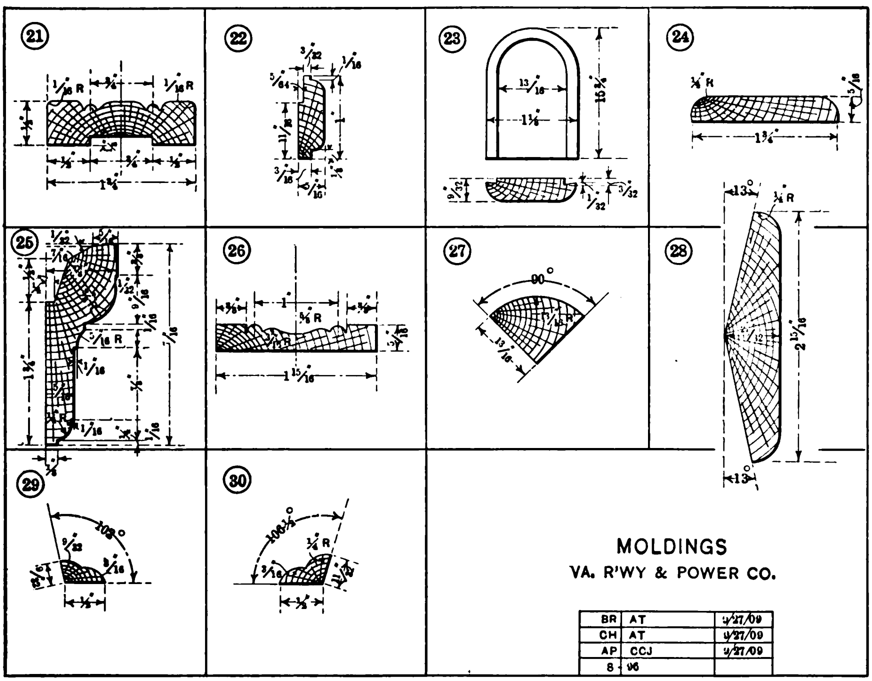


Device for holding machine screws.

A is a piece of iron 3/4 in. wide, 1/8 in. thick and 4 in. long, tapered down to 3/8 in., so it can be adjusted to fit any size head. Bevel the edge so it will fit slot in the screw as in *A*. *B* is made from the same size iron, 2 1/4 in. long. *C* and *D* are 2 in. high.

Cut a slot 1/8 in.×3/4 in. in *C*, and in *D* 1/8 in.×1/2 in. Drill a 1/4-in. hole in the center of *B*, as shown in the sketch, to hold the screw. Place the screw into the 1/4-in. hole in *B* and slide the tapered bar *A* through the oblong hole in *C* into the screw slot and then through the oblong hole in *D*. Strike the end of the bar lightly with a hammer, so it will hold the screw firmly. The jig can be clamped (*C*) into the vise and the necessary work done.

Standard Sizes in Shop Drawings.—Standardization in drawings may not be as profitable as in apparatus, but it is both economical and con-

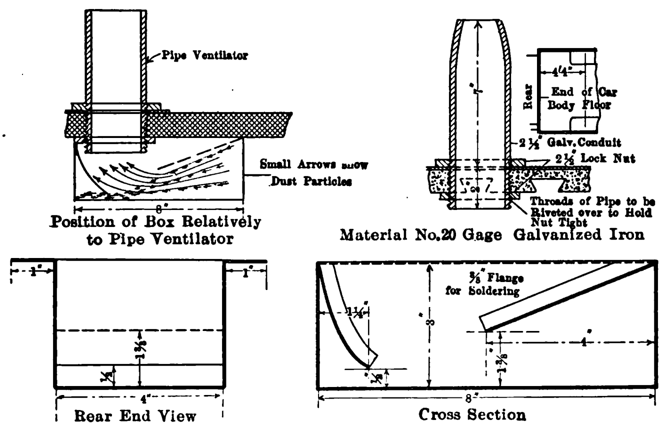


Standard Richmond shop print for car moldings.

venient to confine practically all shop prints to two sizes, one for details and the other for assembling. This is done by the Virginia Railway & Power Company, which uses sheets 9 in.×14 in. and 14 in.×22 in. in size. The extent to which this company records its standards for the education of the employees may be judged from the fact that even car-molding drawings like those reproduced are made and indicated by style numbers. This practice not only helps the mill-room, but eliminates all confusion in the ordering of supplies, because the storekeeper is not left in doubt as to what is wanted.

Renewing Cement Floors.—Early in 1911 the Hudson Companies found it necessary to renew the top surface of the composition cement car flooring, which had worn out at the doors and opposite the seat risers after two years' service. In placing the new flooring two important changes were applied as follows: The flooring was laid perfectly flat instead of being crowned, so that there is no thinning out at the very place at which the wear is greatest, namely, opposite the risers, where there is a great deal of shuffling by passengers; the top dressing is 1/2 in. instead of 3/8 in. thick. The underlying layer of these floors, which was not touched, is about 7/8 in. thick at the deepest point of the keystone section floor. The cement-covered area of the floor section and vestibules of a car is 265 sq. ft. The net cost of removing the top dressing is $2 and the cost of laying the new dressing $4 per car. The cement, after requiring some five hours' preparation, will set sufficiently well over night to permit the car to go into service.

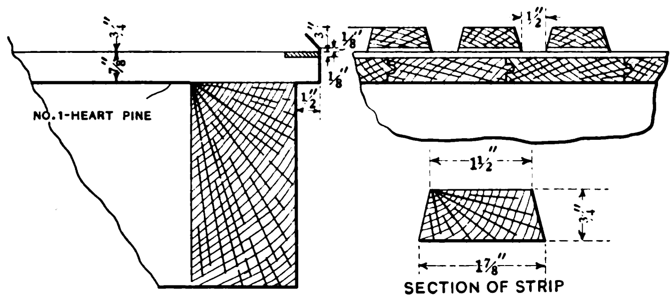
Clean Air for Single-end Arch-roof Cars.—Like so many other companies, the Montreal Street Railway has adopted the single-arch roof,



Montreal cars—deflector box for obtaining purified air.

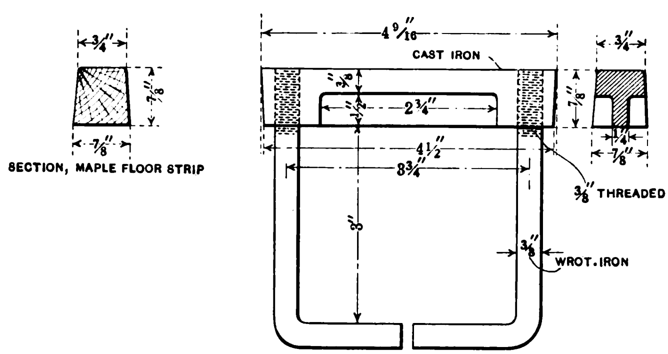
the first cars of this type having been ordered during December, 1912. Each roof is fitted with eight ventilators, which are placed in pairs. The difficulty of supplying clean air from openings near the street level has been solved by means of the dust deflector box shown in an accompanying drawing. This consists merely of an open galvanized iron box containing a pair of deflectors. For the single-end cars standard in Montreal these deflectors are so placed that the dust particles of the entering air are forced downward and out at the rear as they impinge against the larger deflector. The cleansed air passes through the floor of the car via a 2 1/2-in. pipe up to the electric heaters. The deflector box avoids the troubles due to clogged screens, while the effectiveness of the ventilation scheme as a whole is clear from the fact that the car windows will not collect frost even in the most severe weather.

Reducing Platform Wear by Using Reinforcing Strips.—The Virginia Railway & Power Company, Richmond, Va., covers all of its car platforms



Platform floor stripping over steel plate at step, Richmond.

with maple strips similar to those used inside the cars. To avoid replacing the entire platform when the flooring at the step is worn out, the mechanical department now inserts an iron strip flush with the pine underflooring and extending the entire width of the platform at the steps, as illustrated. This reinforcing strip is 1/8 in. thick and 1 in. wide. When the maple strips at the step are worn down, new ones are inserted for the necessary length, but no change whatever is made in the pine flooring below because of the protection afforded by the metal.



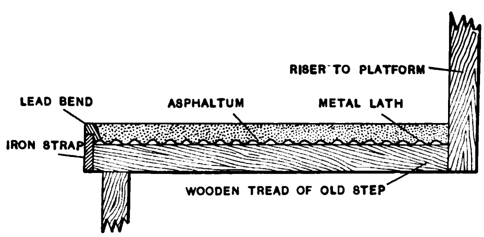
Trap-door lift, Richmond.

An Unusual Trap-door Lift.—Many motor trap doors are raised either by means of a ring fastened to the floor in a depression made by cutting away a portion of the floor strips or by placing the top of a lift yoke between the adjacent strips, which have been beveled for the hand.

Both of these methods are open to the objection that people with high-heeled shoes, particularly women, may trip in these holes, and thus find an excuse for injury claims. This possibility is avoided by the design of trap-door lift devised by the mechanical department of the Virginia Railway & Power Company. This method is shown in the lower drawing on page 10. Enough of one strip is cut away over each trap door for the insertion of a piece of cast iron 4 9/16 in. long. This casting is exactly as wide as the strip and flush with the rest of the floor. It is made as an inverted "U." The rest of the lift consists of 3/8-in. wrought-iron rods threaded into the top piece as shown. The usual space between the strips is ample for the insertion of the fingers without requiring any depressions in the floor.

Steel Car Panels over Wood.—Owing to the climatic conditions in Richmond, Va., the wooden panels on the cars are frequently cracked. Instead of replacing them with new wood panels the Virginia Railway & Power Company covers the old panels with steel of No. 18 gage. These steel sheets are screwed on under the old side moldings and when painted they cannot be distinguished from wood. In fact, there are many cars which have wood panels on one side and steel-covered panels on the other. When steel panels are applied, they are continued past the belt rail without a break and this prevents the rotting which occurs when water from the belt rail gets inside the car between the joints of the wooden half-panels. The plates are shaped in the company's shops and are applied whenever it is found that a large number of the wooden panels are split.

Home-made Safety Tread.—The mechanical department of the Cedar Rapids & Marion City Railway Company, Cedar Rapids, Ia., has devised

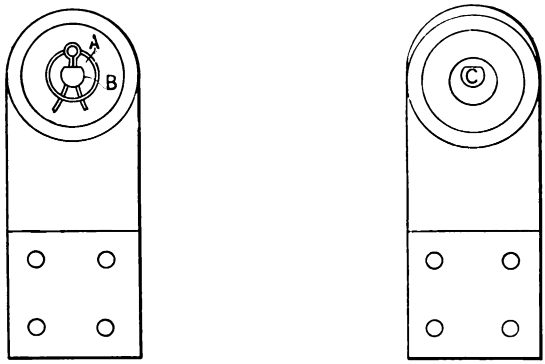


Home-made safety tread for surface car steps, Cedar Rapids.

a very serviceable yet economical tread consisting of a section of metal lath tacked to the old wooden tread over which is spread a mixture of asphaltum saturated with sand. The asphaltum wearing surface is approximately 1/2 in. thick and the metal lath acts as a bond between it and the 1 1/4-in. oak tread. In order to provide for equal wear and also to protect the edge of the tread against excessive rate of wear, a 3/16-

iron strap is screwed to the edge of the wooden tread. This strap projects about 1/4 in. above the top of the wooden tread and the edge is then brought to the same level as the asphaltum by pouring a lead bead in a mold which brings the edge of the tread 1/4 in. above the iron strap. The bead is held firmly in place by extending it downward in back of the strap, thus giving it a bond to the metal lath. The wearing qualities of the lead and the asphaltum mixture are about the same so that step wear will be uniform over the entire surface. This lead bead and iron strap are applied before the asphaltum mixture. A section of this tread is shown in the illustration.

Babbit Bearing for Door Rollers.—Most door rollers are equipped with brass bushings *A*, as shown in Fig. 1, which can be renewed when



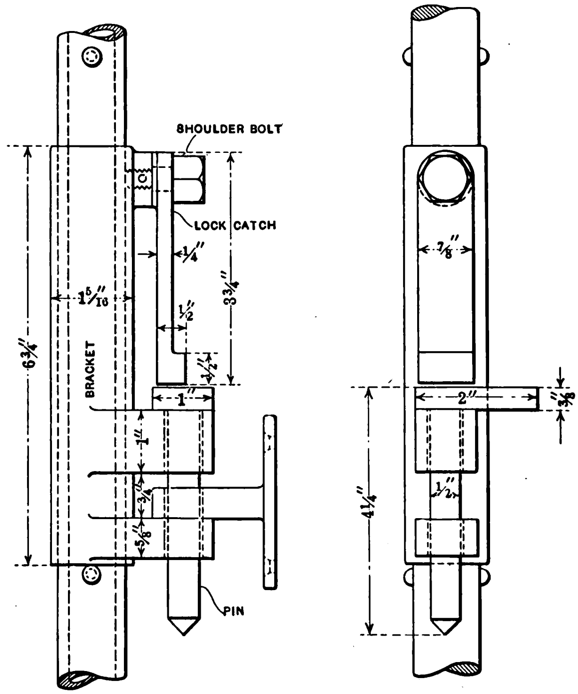
Figs. 1 and 2.—Replacing the brass bushings of door rollers with babbitt bearings.

worn out. The stud *B* on the casting is made with a flat place, so that the bushing will not turn. Any lost motion on the stud or the bushing, or when the door rides on the bottom, causes a great deal of trouble.

To remedy this, first remove the bushings, then tin the cast-iron stud to permit the melted babbitt to adhere to it. If the door rides on the bottom and is to be lifted up draw the wheel down off center as much as the door is to be lifted (see illustration "C").

Oil the bearings of the wheel so that the melted babbitt will not stick. Then pour in enough babbitt to make it flush with the wheel. The surplus babbitt can then be chipped off and the washer and cotter pin replaced. A repair shop man, who is connected with a medium-size electric railway, says that he has tried this method and by its use a pair of bearings can be repaired in a very short time, and when once repaired in this way they will give much better service than with brass bushings.

Preventing Accidents from Opening Gates.—At one time, the Virginia Railway & Power Company, Richmond, Va., was troubled by platform accidents due to passengers falling off the car by leaning against and thereby opening the old-style folding gates. These accidents were successfully eliminated by devising a gravity gate latch as shown in the accompanying drawing. It will be observed that the gate is held by a pin which is prevented from rising out of the bracket casting by the swinging lock catch above. This lock catch is so placed that it cannot be swung out of position by passengers leaning against the gates so that there is no possibility for the holding pin to be shaken out of the bracket.

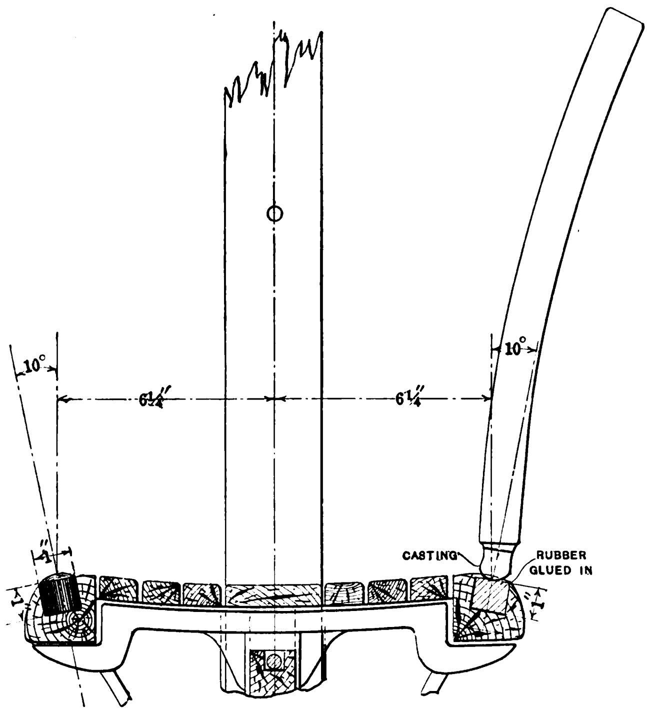


Platform gate for preventing accidents, Richmond.

An Insulated Roof for Electric Locomotives.—The Fort Dodge, Des Moines & Southern Railroad, Boone, Ia., which is now being operated at 1200 volts d.c., has insulated the entire roof of each engine with wooden slats. The nailing strips, 3-in.×6-in. yellow pine, are cut to fit the contour of the roof and bolted to it. The slats are 1-in.×2 1/2-in. yellow pine applied so as to leave a 2-in. space between them. The addition of this protective feature is simple and inexpensive and adds greatly to the safety of trainmen, who in emergencies may have to mount the engine roof.

Protecting Rattan Seats.—The Richmond Railway & Power Company, Richmond, Va., finding that its passengers have the usual tendency to place their feet on the corner rattan seats, protects the latter by attaching along the edge a wooden strip 1 1/2 in. high and 3/8 in. thick.

Protecting Rubber Seat Buffers on Open Cars.—The proverb "Out of sight out of mind" has been made to apply in Hartford to the preservation of car equipment by concealing the rubber buffers in the seats of open cars instead of following the usual custom of attaching them to the edge of the seat back, where they are sure to tempt the passenger who



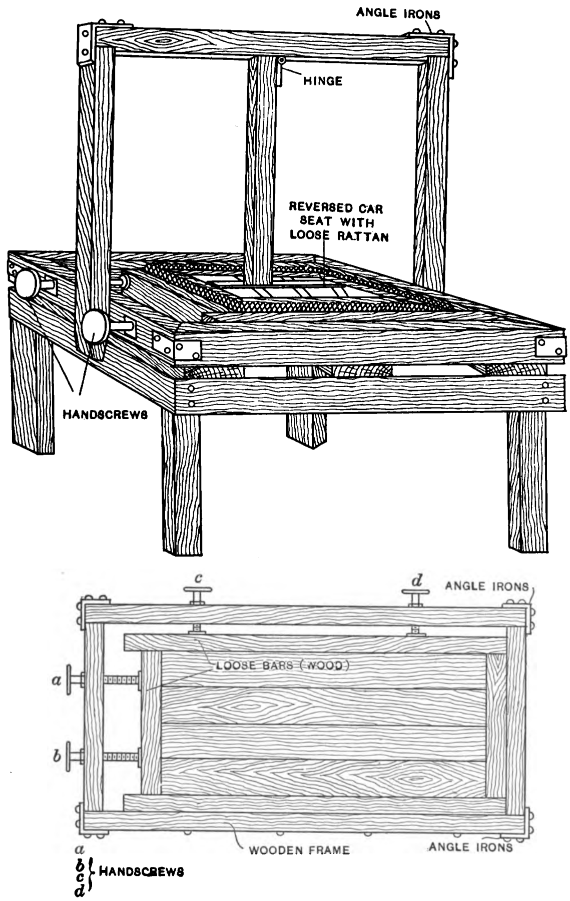
Depressed rubber buffers in benches of open cars, Hartford.

owns a pocket knife. As shown in the accompanying cross-section, the buffers are depressed flush with the bench, the shock from the seat backs being transmitted by rounded castings.

Seating and Curtain Practice in Brooklyn.—The Brooklyn Rapid Transit System does all building and repairing of rattan seats and chairs at its East New York shops and all curtain and miscellaneous leather work at the Thirty-ninth Street shops in conformity with its policy to specialize the work of the mechanical department as much as practicable.

Long experience with the troubles incident to rattan seats has led to several improvements in construction which may be of interest to other electric railways which have not enjoyed the benefits of expert labor for this class of maintenance.

The rattan seats, as originally purchased, were made very much alike except that in one form the strips of flat spring steel to which the spiral springs were attached were carried over the top of the wooden frame and nailed thereto; in the other form the steel strips terminated in a groove 1/2 in. deep and 1/4 in. from the outside of the frame, the nails being tacked through the side of the frame. In the first construction the nails

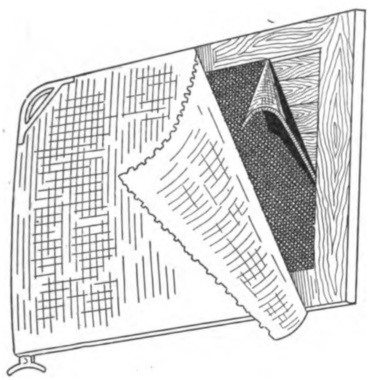


Press for stretching rattan over seat before nailing, Brooklyn.

would gradually work their way up and eventually manifest themselves by penetrating the rattan and tearing the clothing of passengers. The second construction gave little trouble from nails, but in both cases the steel strips would break at the bends and their sharp, jagged edges would rip the rattan and cause even more damage than the nails. The seats, as now rebuilt, give absolutely no trouble from either of these sources.

Furthermore, the new construction makes it possible to avoid much waste in spring steel because it is possible to use shorter lengths and these are often made up from old springs which formerly were discarded.

As shown in one of the sketches, the strips are riveted to the spiral springs as before, but they are carried only to within 1/2 in. to 1 in. of the side frames. The edges of these strips are bent back beforehand by a special machine, so that there is no possibility of sharp edges cutting through the seating. Over each spring steel strip there is copper-riveted a strip of canvas. This canvas is glued to the framework and carried around and nailed to the bottom of each side piece. As the nails are in the bottom of the frame their working out can do no damage. After these canvas strips have been installed the entire seat area is covered with a single piece of glued canvas which is tucked over and nailed to the bottom of the end-frame pieces. This large canvas cannot be tucked over the side frames because of the limited clearance afforded by the seat rails. Finally, as a cushion for the rattan, a piece of cow-hair felt, 1/2 in. thick, is glued to the large piece of canvas. In order to economize material the cow hair is sometimes glued on in two or three pieces. Where one piece is used glued retaining strips of canvas are nailed on at the ends only, but otherwise a strip of canvas is placed over each joint in the felt and the ends of the strip are tacked to the under side of the framing to prevent the shifting of the felt.



Rattan seat back, Brooklyn.

When the seat is ready for its covering of rattan it is placed in a press which is supplied with a bed of the proper size. One end and one side piece of the bed frame are adjustable, each being operated by means of a pair of screws, as shown in the sketch on page 15. The seat covered with the loose rattan is placed upside down in the bed. Then the screws are applied while the seat springs are compressed from above by a hinged lever which presses against a cross-bar placed over the seat slats. Thus the entire seat is under compression to permit the rattan to be properly tightened for nailing. The cow-hair felt used for the backs is 1/4 in. thick.

Curtains are repainted at definite intervals, even if in good condition otherwise. Previously it was the custom to use two coats to secure a glossy finish, but it has been found possible to attain the same results with one coat by adding a thinning solution of Japan drier. The freshly painted curtains are hung on rollers and permitted to dry for ten hours, although they are fairly dry for use in little more than half that time.

A very important feature in connection with the operation of this department is the scrap collecting and handling system. The inspection and maintenance depots must send to this central shop all discarded curtain and other material which it uses, no matter in what condition such articles are. In this way it is possible to reclaim many springs, rods, screws, pieces of curtain cloth, etc., which otherwise would go to the scrap heap as waste.

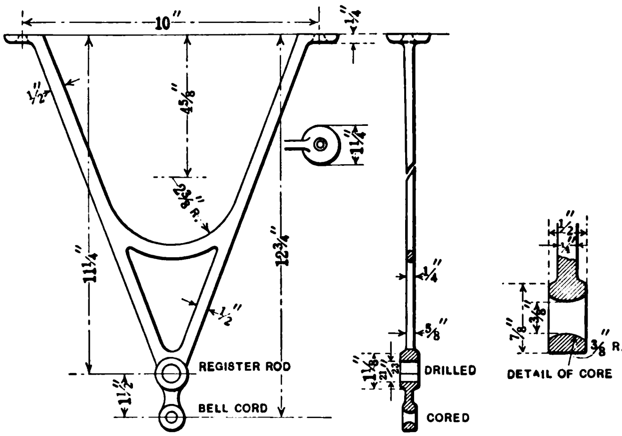
Easel for Curtain Painting.—The sign painter at the Anderson shop of the Indiana Union Traction Company has rigged up an easel which has been found very convenient during the painting of the curtains for the car destination signs. An illustration of this easel with a curtain on it is shown. The curtains used in the destination sign boxes are 21 3/4 in. wide, 10 ft. long and carry the names of eighteen towns in letters 4 1/2 in. high, spaced according to the length of the name. The easel on which these curtains are painted is so arranged that duplicate curtains can be made without the use of a stencil or any lining.

Easel for painting sign curtains.

When a curtain is to be painted the top of the cloth is tacked to a strip of wood which rides on the front of the two main legs of the easel. The curtain is supported by a weight carried on a string which is passed over the top of the easel. The end roll of cloth is carried in two supports made of spring steel bent into hook shape and fastened to the lower cross brace of the easel. Just above this cross brace is a sheet of glass about 30 in. × 24 in., against which the cloth to be painted lies. This glass forms a backing for the cloth and holds it in smooth shape while the paint is being applied.

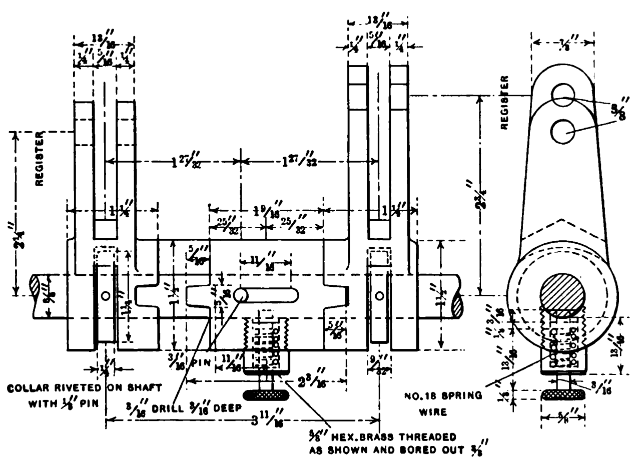
If a curtain is to be duplicated one of the type desired is partly unrolled and so placed that that portion of the lettering to be copied lies flat against the front of the glass. The rolls of the cloth are supported behind the glass in suitable hooks. The blank cloth then is hung in front of the glass directly over the pattern curtain. As the curtain material is translucent the letters on the first curtain plainly show through the blank cloth and may easily be copied without the use of stencils.

Richmond Bell and Register Fixture.—The top drawing on page 18 shows a rather interesting cast-brass bell cord and register rod fixture installed in many of the cars operated by the Virginia Railway & Power Company, Richmond, Va. This arrangement is built for installation along the center line of the car and has a wide opening at the top to clear the lighting fixtures. The most interesting points about this bell and register fixture, however, are the bell-cord hole and the spacing between the cord and register rod. It will be observed that the hole for the bell cord is beveled, thereby avoiding the creation of sharp edges



Register rod and bell cord bracket, Richmond.

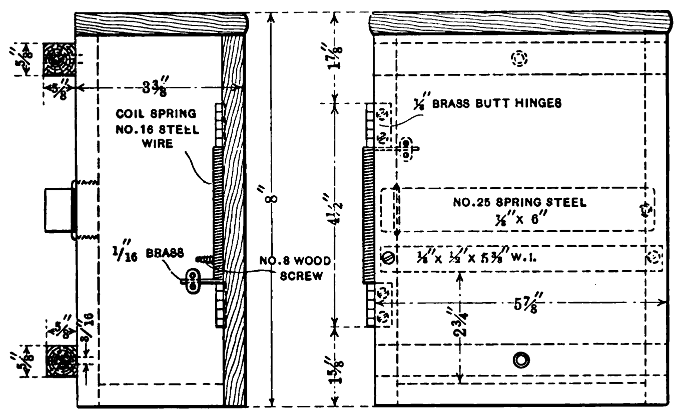
which would soon cut into the rope. This provision of a space of 1 1/2 in. between the bell-cord and register rod was due to the fact that when a smaller clearance was used, the conductors could not operate the bell rope without bruising their knuckles against the rod.



Mechanism for ringing up two registers from one rod, Richmond.

Ringing up Two Registers from One Rod.—Owing to a peculiar condition in connection with its Lakeside line, the Virginia Railway & Power Company, Richmond, Va., is obliged to use two distinct fare registers. One of these registers records all fares received up to a given point after which the conductor rings up his collections on the other register. As it was desirable to operate both registers from a single center rod and to have both machines at the same end, the mechanical department devised the clutch and lever arrangement shown in the lower drawing on page 18. The clutch has a radial lug on each end to fit into a corresponding slot in the lever casting on either side. By pulling down its spring latch, the clutch can be pushed along the rod and locked into the lever connections of the machine which is to register the fares.

Conductor's Transfer Box.—The average conductor finds the carrying of three or four transfer pads in his pockets a rather irksome task and is



Conductor's transfer box, Richmond.

likely to deposit the extra pads and other papers in some place like the sand box. To avoid this, the Virginia Railway & Power Company, Richmond, Va., has installed a transfer box in every one of its cars. As shown in the accompanying drawing, the box is 8 in.×5 7/8 in.×3 3/8 in. in size. It is made of 7/16-in. wood to match the inside finish of the car. The door is made self-closing through the medium of a coil spring of No. 16 steel wire.

Car Wiring Methods in Denver.—The Denver City Tramway revised its car wiring methods in 1911. The main cable is now being carried above the car floor at the side of the car in wood boxing, compounded on the inside, and cars are being cleaned by compressed air to avoid the penetration of moisture. All cables are of individual flame-proofed wires and the covering on the entire cable is also flame-proofed. Where the leads to motor and resistances pass under the car framing they are supported on porcelain or composition insulators and the bottom of the car framing is protected by sheet iron.

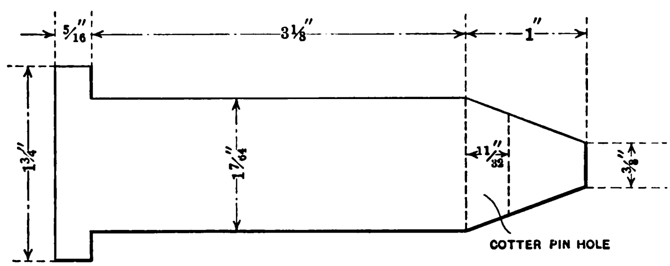
The connection board under the car is provided with asbestos wood facing and barriers and is backed by sheet metal. The rheostats have sheet metal protection. Light and heater circuit wiring is of "slow-burning" wire except that in the light wiring overhead ordinary rubber-covered wire is used with a special grooved hard-wood molding with grooves spaced so as to take strap hangers, receptacles and molding supporting screws, the molding being run down the center of cars and backed by the maple ceiling board. There are no wire joints in this molding. The light and heater circuit fuses are mounted on asbestos wood panels on the front platforms, where, owing to design of cars, they are inaccessible to the general public. In other portions of car wiring, where necessary, flexible tubing protection is used.

Excluding Drafts from Pay-within Cars.—On the system of the United Traction Company, Albany, N. Y., the vestibule doors differ from common construction in several interesting points. They have no rubber buffers but fit snugly in the grooves of an intermediate post. This method insures the air-tight joint so desirable in a car with bulkheads—an end which cannot be obtained when one rubber buffer bears against another. Some trouble might be anticipated from the pinching of passengers with these doors, but in two years' operation of rebuilt cars with such doors, no passengers were caught in this manner. Another feature for excluding drafts is that the doors close 7/8 in. below the vestibule floor instead of at the platform level.

III

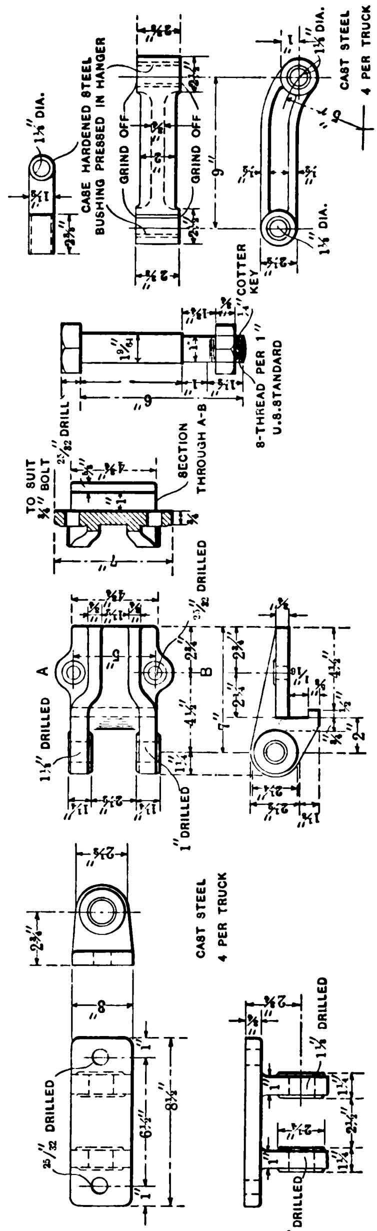
BRAKE EQUIPMENTS AND BRAKE RIGGING

A Simple Improvement in Brake Rigging Pins.—The tapering of the ends of brake rigging pins has been found by the Syracuse, Lake Shore & Northern Railway and allied lines to result in a considerable saving of time in assembling. The holes in both jaws and brake beams are lined with hardened tube steel bushings and make a close fit on the pins. Without the taper it requires some time and effort to get the holes lined up sufficiently to insert the pins. With the tapered end, as shown in the accompanying cut, the pin acts as a drift in lining up the bushings.



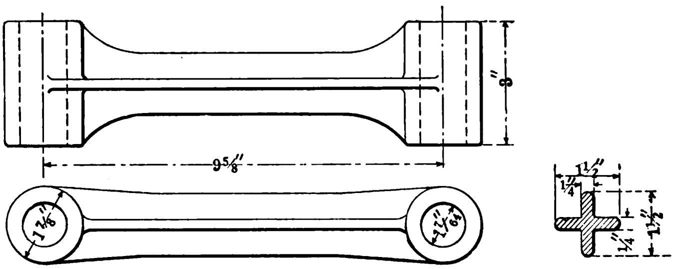
Tapered pin for brake rigging, Syracuse.

Brake Hangers in Richmond.—The following drawings show the details of the brake hanger designed by the mechanical department of the Virginia Railway & Power Company, Richmond, Va., to take the place of various hangers originally furnished with the trucks. The original hangers were superseded because whenever any part, such as the upper casting, lower casting or hanger links, wore out, it was necessary to scrap the entire hanger. In this new hanger a case-hardened pin, made with a shoulder, locks rigidly against the upper castings so that nothing can wear on the latter. This pin is locked in the lower casting in the same way so that the lower casting is also saved from wear. The hanger links between the two castings are provided with case-hardened bushings both top and bottom to take up all hanger abrasion. When these bushings are worn out, nothing more than a hammer is necessary to knock out the old bushings and press in a new one. It will be seen that only the pins and bushings of this brake hanger require renewal, so that the most costly parts need be made only once.



Top and bottom castings and links and bolts of brake hanger, Richmond.

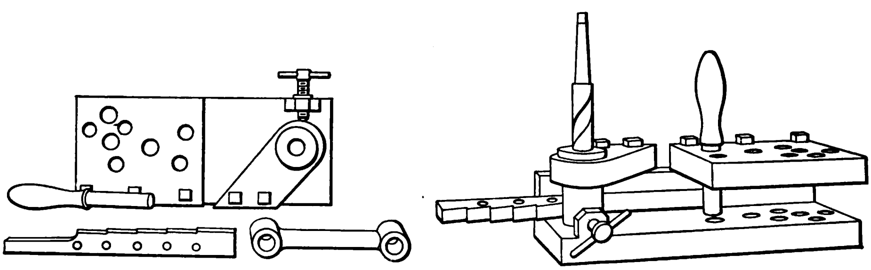
A Light-weight Brake Hanger.—A saving in weight of brake rigging of nearly 50 lb. per car has resulted from the adoption by the New York State Railways, Rochester Lines, of the form of hanger shown in the accompanying figure, which was designed by G. M. Cameron, master mechanic. On the basis of a cost of 5 cents a year for hauling a pound of car weight, this reduction saves $2.50 annually per car. The hanger is so proportioned as to utilize the steel to the best advantage. All bearings



Light-weight brake hanger, Rochester.

are easily replaceable hardened-steel bushings, so that, except for breakage, the life of the hanger is unlimited.

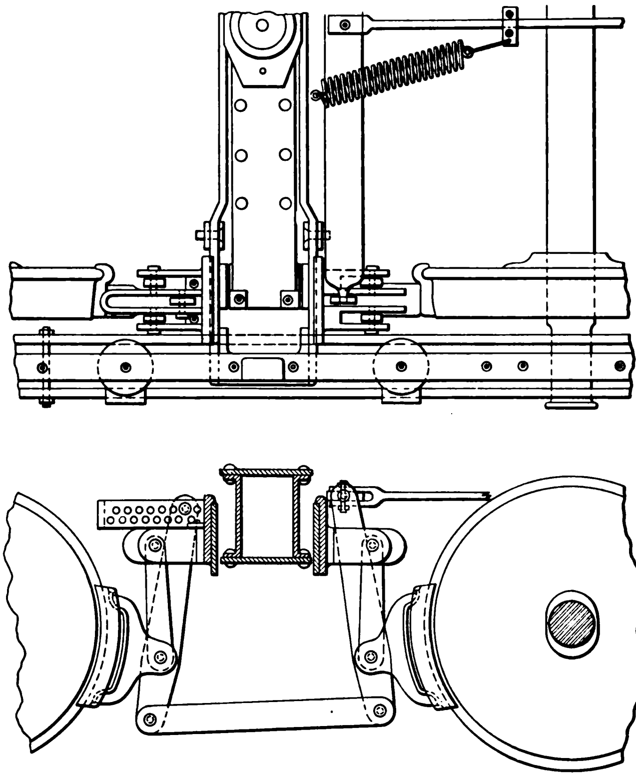
Drilling Jig for Brake Hangers.—The accompanying two cuts show the details and assembly of a drilling jig which was developed by the Toronto Street Railway to insure the accurate spacing of the holes in the brake hangers of different types of trucks.



Details and assembly of device for accurate drilling of brake-hanger holes, Toronto.

Improved Truck Brake Rigging.—The shop forces of the Chicago, South Bend & Northern Indiana Railway, South Bend, Ind., rebuilt in 1910 the brake rigging on eight double-truck cars equipped with St. Louis No. 23-A, M.C.B. type trucks and introduced several features which are said to improve the braking action and simplify maintenance and adjustment of the parts. The improved rigging does away with radius bars, offset brake levers and heads and is so designed that the slack can be taken up on the road without the use of any tools.

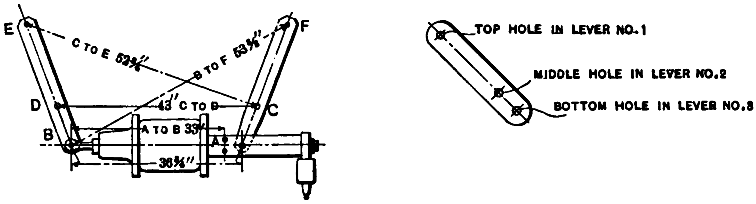
The truck brake rod extends under the center of the car body and is attached by a clevis and pin to the center of a brake beam connecting the top ends of the two live levers. This brake beam is a 1-in. × 4-in. flat bar reduced at the ends to 1 1/4 in. in diameter. A release spring with one end fastened to the truck transom is clamped to the brake rod. The live levers are made of 7/8-in. × 3-in. bars 28 in. long and the bottom truck connections are made of two bars 2 in. × 5/8 in., bolted together



Improved brake rigging for M. C. B. trucks, South Bend.

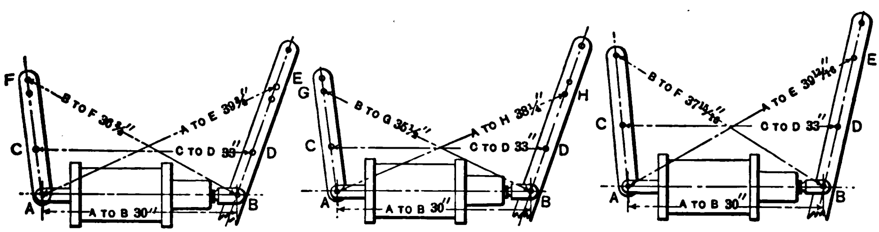
with washers 15/16 in. thick inserted between the bars. Special cast-iron brackets which are bolted to the truck transoms support the brake hangers and serve as guides for the live and dead levers to prevent the side displacement of the levers when the truck is on a curve. A single pin extends through the brake head to connect the links, levers and heads. A slack fork is bolted to the top of each bracket which guides the dead lever. The slack forks are made of forged metal and are provided with 16 pairs of staggered holes. A pin is placed through one pair of these holes to support the upper end of the dead lever, and by moving this pin it is possible to adjust the brakes. This is done by shoving the dead lever away from the transom until the shoes are close to the wheels and then placing the pin through the nearest holes. These slack forks are placed only on the dead-lever side of the truck. The cast-iron brackets which carry the brake hangers and serve as guides for the top ends of the live levers are interchangeable.

Some of the advantages which were realized after this brake rigging was installed were the following: Ease of adjustment, it being possible to



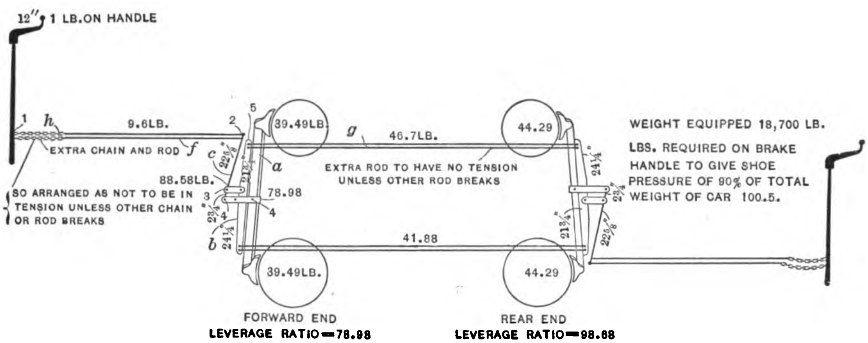
Using jigs to set levers for 10-in. brake cylinder, and lever hole numbering, Philadelphia.

take up the wear on the brake shoes on the street without the use of tools; simplicity of construction, all parts being duplicates for opposite sides of trucks and practically all parts being standard for all four corners of trucks; elimination of radius bars, offset shoe heads and levers; simple and direct release mechanism. A rigging similar in principle has been applied to Brill No. 27-E and the same adjustments to McGuire No. 39 trucks.



Using jigs to set cylinder levers for Brill 27-G, Curtis D 2 and maximum traction, Brill maximum traction and Curtis C. I. trucks, Philadelphia.

Instruction Prints and Jigs for Gaging Brake Rigging.—The tendency to introduce exact methods in shop work is admirably illustrated by the brake rigging adjustment practice of the Philadelphia Rapid Transit Company. It is well known that poor braking and unequal brakeshoe wear are due partly to errors in leverage dimensions and to inaccurate adjustments by the shop men. To eliminate trouble from both of these causes the Philadelphia company developed during 1909 a series of accurately calculated jigs for setting the cylinder levers of its numerous types of brake rigging. All that the brake inspector is required to do is to see that the distances between certain points on these levers are to gage as shown by the jigs. These gaging points are indicated on blueprints of the style reproduced in the engravings on page 25. The prints are 6 in.×4 in. in size and are bound for handy pocket use with other drawings of brake rigging parts such as dead and live levers, cylinder tie rods and push rods, brake beams, etc. One of the latter prints shows the standard method of numbering holes in all levers.



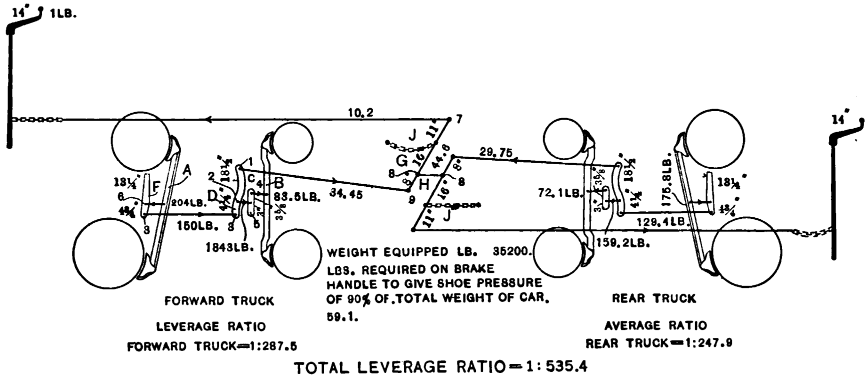
TOTAL LEVERAGE RATIO = 167.56

Brake leverage diagram, single truck-cars, Brooklyn.

TABLE OF STRESSES
Figured at 100 lb. on brake handle

Rods and Levers			Pins (single shear)		
Mark	Size	Tensile stress lb. per sq. in.	No.	Size	Shearing stress lb. per sq. in.
a	1"×5"		1	½" eye belt	4,890
	½"×6" reinforce	15,550 lb.			
	1"×5"				
b	½"×6" reinforce	14,300 lb.	2	⅝"	3,129
c	1"×2⅞"	16,580 lb.	3	1⅛"	8,912
d	⅝"×2½"	10,800 lb.	4	1⅛"	7,946
e	⅝"×2½"	9,628 lb.	5	½"×2" key	4,670
f	⅝" rod	3,129 lb.			
g	⅞" rod 1" T-bckle	8,491 lb.			
h	⅜" chain	Total stress 960 lb.			

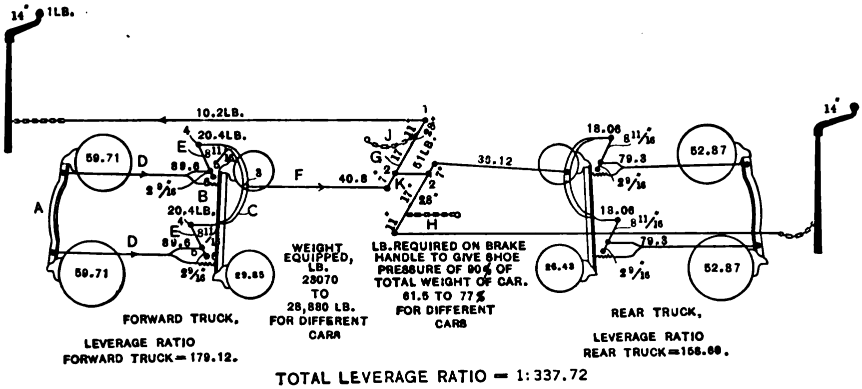
Brake Leverage Diagrams at Brooklyn.—On the Brooklyn Rapid Transit System brake leverage diagrams and tables of stresses in rods, levers and pins have been calculated and recorded in blueprint form for all classes of cars. The six accompanying drawings show the company's



Brake leverage diagram 045 maximum traction truck, Brooklyn.

TABLE OF STRESSES
Figured at 59.1 lb. on brake handle

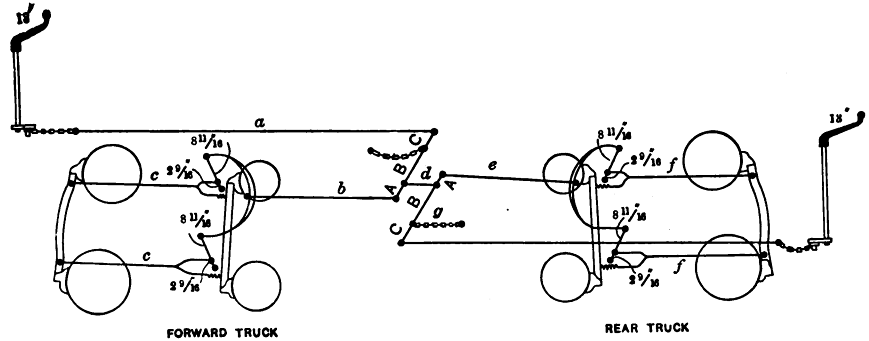
Rods and Levers		Pins	
Mark	Tensile stress lb. per sq. in.	No.	Shearing stress lb. per sq. in.
A	21,790	1	4,562
B	17,200	2	13,740
C	17,000	3	11,170
D	14,510	4	3,110
$E^{\times}$ –fulcrum beam	15,860	5	3,758
F	20,035	6	15,180
G	13,830	7	838
H	4,614	8	4,190
$J^{\times\times}$ – $\frac{3}{8}$" chain	6,654	9	3,352



Brake leverage diagram, Brill maximum traction truck, Brooklyn.

TABLE OF STRESSES
Figured for 75 lb. pull on brake handle

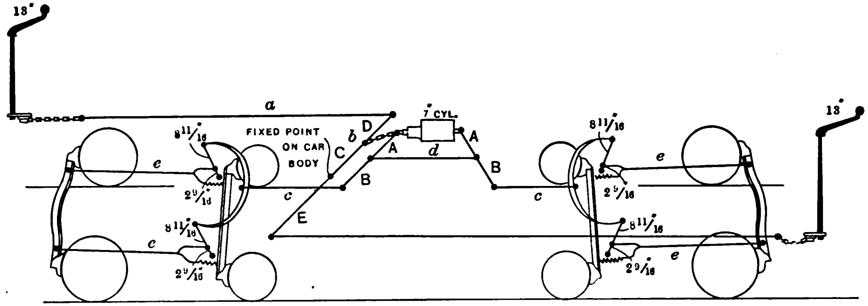
Rods and Levers		Pins	
Mark	Tensile stress lb. per sq. in.	No.	Shearing stress lb. per sq. in.
A	44,534	1	1,272
B	21,144	2	6,361
C	38,350	3	5,089
D	8,167	4	3,463
E	14,266	5	15,212
F	3,896	6	6,604
G	21,102		
H	5,052		
J	5,052		
K	3,600		



Leverage diagram for geared hand brake equipments of surface cars, Brooklyn.

TABLE OF DIMENSIONS AND PRESSURES

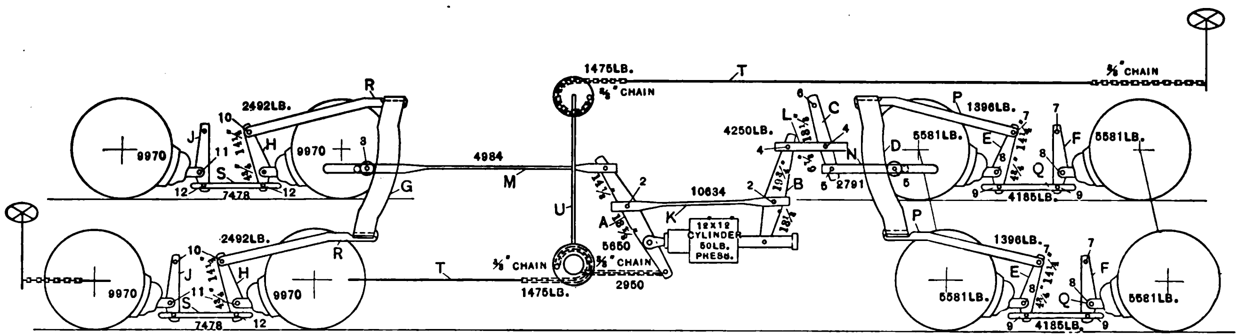
Type of brake	Gear ratio	Weight of car, light, lb.	Leverage ratio. Forward truck	Leverage ratio. Rear truck	Leverage ratio. Total for car	Pull on br. handle to give braking pressure equal to 85 per cent of light wt. of car.	Dimensions A	Dimensions B	Dimensions C	Pressures a	Pressures b	Pressures c	Pressures d	Pressures e	Pressures f	Pressures g
A	42/18	28,150	304.4	269.5	573.9	41.8	7″	17″	11″	724.5	2898	6362	3623	2566	5633	1057
B	34/14	28,150	369.6	327.3	696.9	34.4	7″	17″	11″	724.0	2896	6357	3620	2563	5629	1057
C	34/14	28,510	328.6	290.9	619.5	39.3	7″	17″	11″	735.2	2941	6456	3686	2604	5716	1082
C improved	3/1	28,760	456.6	404.3	860.9	28.5	7″	17″	11″	741.0	2964	6506	3705	2624	5761	1081
a	42/18	28,060	304.4	269.5	573.9	41.7	7″	17″	11″	722.8	2891	6347	3614	2560	5619	1054
c	34/14	28,120	328.5	290.9	619.4	38.7	7″	17″	11″	724.0	2896	6357	3620	2564	5627	1056
B	34/14	27,660	369.6	327.3	696.9	34.0	7″	17″	11″	715.6	2862	6283	3578	2534	5563	1044



Leverage diagram for air and geared air brakes of surface cars, Brooklyn.

TABLE OF DIMENSIONS AND PRESSURES. (Hand Brake).

Type of brake	Gear ratio	Wt. of car, light, lb.	Total lev. ratio, forward truck	Total lev. ratio, rear truck	Total lev. ratio, whole car	Pull reg. on brake handle to give a total brake pressure equal to 85 per cent. of light wt. of car	Dimensions					Pressures at				
							A	*B*	*C*	*D*	*E*	*a*	*b*	*c*	*d*	*e*
A	$\frac{42}{18}$	31,270	209.53	209.53	419.06	63.5	$9\frac{3}{16}$"	$6\frac{13}{16}$"	12"	$12\frac{1}{2}$"	$24\frac{1}{2}$"	1101	2247	3031	5278	6653
C	$\frac{12}{48}$	31,520	372.50	372.50	745.00	36.0	$9\frac{3}{16}$"	$6\frac{13}{16}$"	12"	$12\frac{1}{2}$"	$24\frac{1}{2}$"	1109	2265	3054	5319	6705
B	$\frac{17}{36}$	31,275	314.30	314.30	628.60	42.4	$9\frac{3}{16}$"	$6\frac{13}{16}$"	12"	12"	$24\frac{1}{2}$"	1102	2251	3035	5286	6663



MOTOR END, WEIGHT, 39,750 LB.
BRAKING PRESSURE, 39,880 LB. = 100.4 %

TRAILER END, WEIGHT, 24,800 LB.
BRAKING PRESSURE, 22,324 LB. = 90 %

TOTAL WEIGHT OF CAR 64,550 LB.

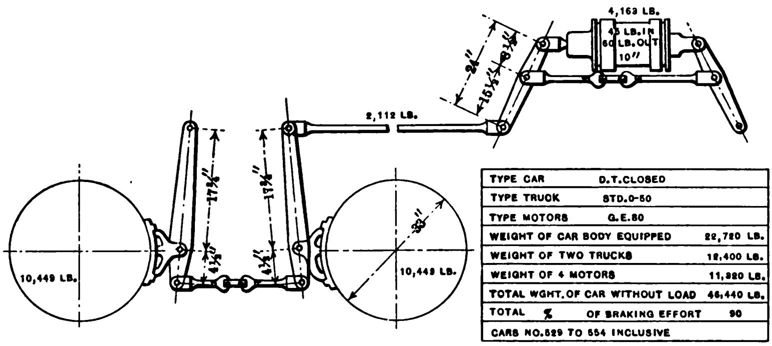
Brake leverage diagrams for elevated cars, Brooklyn.

TABLE OF STRESSES

Levers			Rods			Pins		
Mark	Size	Stress	Mark	Size	Stress	Mark	Diam.	Shear
A	1″×6″	12,610	*K*	$1\frac{1}{4}''$	8,663	1	$1\frac{3}{32}''$	6,013
B	1″×6″	14,280	*L*	$2\frac{1}{2}\times\frac{1}{2}''$	3,091	2	$1\frac{11}{32}''$	7,494
C	1″×4″	7,772	*M*	$1\frac{1}{8}''$	5,014	3	$1\frac{3}{32}''$	5,305
D	$\frac{3}{4}''\times 6''$	10,550	*N*	$2\text{–}3\times\frac{5}{8}$	1,190	4	$1\frac{3}{32}''$	4,522
E	$\frac{3}{4}''\times 5''$	9,200	*P*	$2\times\frac{7}{8}''$	1,215	5	$1\frac{3}{32}''$	2,970
F	$\frac{3}{4}''\times 5''$	9,200	*Q*	$2\times 2\frac{1}{2}\times\frac{5}{8}$	2,978	6	1″	1,630
G	1″×7″	10,370	*R*	$2\times\frac{7}{8}''$	2,170	7	1″	1,777
H	$\frac{3}{4}''\times 5''$	16,460	*S*	$2\text{–}2\frac{1}{2}\times\frac{5}{8}$	5,319	8	$1\frac{11}{32}''$	3,933
J	$\frac{3}{4}''\times 5''$	16,460	*T*	$\frac{3}{4}''$	3,340	9	$1\frac{11}{32}''\text{–}1\frac{1}{8}$	7,523
U	Shaft	14,100				10	1″	3,173
	$1\frac{3}{4}''$ sq.	Torsion 6,435				11	$1\frac{11}{32}''$	7,026
						12	$1\frac{11}{32}''\text{–}1\frac{1}{8}''$	4,210

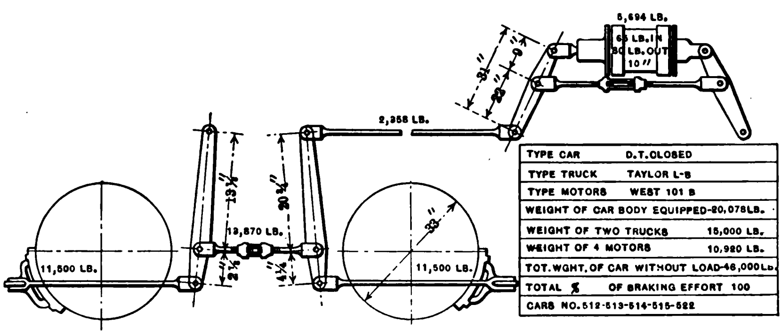
practice in 1913 for as many classes of cars equipped with air and geared hand brakes.

Brake Leverage Diagrams at Hartford.—The brake leverage diagrams which are supplied to the men at the Hartford shops of the Connecticut Company are supplemented by braking study sheets of the type shown.



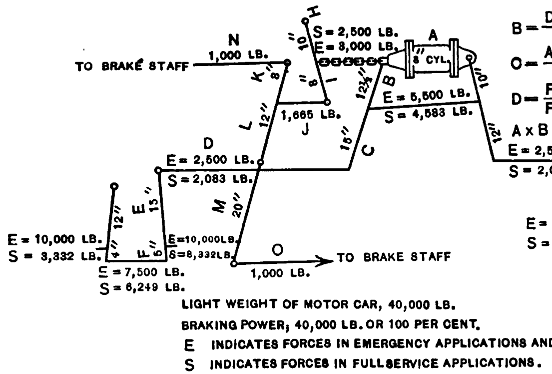
Brake leverage diagram for cars with cast-iron wheels, Hartford.

These offer a convenient means to determine accurately the best leverage arrangements and choice of air-brake cylinder sizes for given air pressures. It will be observed that this sheet includes the area of 7-in., 8-in. and 10-in. cylinders, which are the present standard sizes on this system. The dimensions of the auxiliary reservoirs required in each case are also given.



Brake leverage diagram for cars with steel wheels, Hartford.

The utility of these braking sheets is readily apparent in those instances when the motorman turns in a car for poor braking. Leverage measurements are made, the air pressure is determined and the dimensions of the cylinder are taken. From his instruction sheet covering the car under examination the shop superintendent can soon determine the braking pressure and leverage distances required to give the proper braking



$$B = \frac{D \times (B + C)}{A + D} \qquad J = \frac{A \times H}{H + I}$$

$$O = \frac{A \times (B + C)}{A + D} \qquad N = \frac{J \times L}{K + L}$$

$$D = \frac{F \times G}{F + E} \qquad O = \frac{J \times L}{M}$$

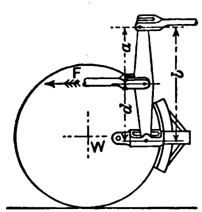
$$A \times B = C \times D$$

The following table gives the forces exerted upon the pistons of the different sized cylinders with pressures of 50 lb., 60 lb. and 70 lb. per sq. in.

Size of Cylinder	16″,	14″	12″,	10″,	8″	7″
Area of Cylinder				78,54 sq.in.,	50,27 sq.in.,	38,48 sq.in.
50 lb. Pressure	10,050	7,700	5,650	4,000	2,500	1,950
60 lb. Pressure	12,050	9,200	6,700	4,700	3,000	2,300
70 lb. Pressure	14,100	11,800	7,900	5,500	3,500	2,700

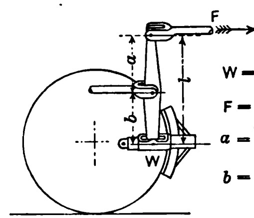
AUXILIARY RESERVOIRS USED WITH DIFFERENT SIZES OF BRAKE CYLINDERS.

10″x33″ Auxiliary Reservoirs with 8″ Brake Cylinder of all kinds
12″x33″ " " " 10″ " " " " "
14″x33″ " " " 12″ " " " " "
16″x33″ " " " 14″ " " " " "
16″x42″ " " " 16″ " " " " "



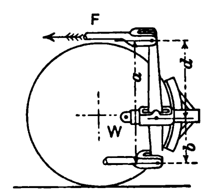
$$W = \frac{F \times a}{b}$$
$$F = \frac{W \times b}{a}$$
$$a = \frac{W \times b}{F} \text{ OR } a = \frac{W \times d}{F - W}$$
$$b = \frac{F \times a}{W} \text{ OR } b = \frac{F \times d}{F - W}$$

APPLIED FORCE BETWEEN FULCRUM AND DELIVERED FORCE



$$W = \frac{F \times a}{b}$$
$$F = \frac{W \times b}{a}$$
$$a = \frac{W \times b}{F} \text{ OR } a = \frac{W \times l}{F + W}$$
$$b = \frac{F \times a}{W} \text{ OR } b = \frac{F \times l}{F + W}$$

FULCRUM BETWEEN APPLIED AND DELIVERED FORCE



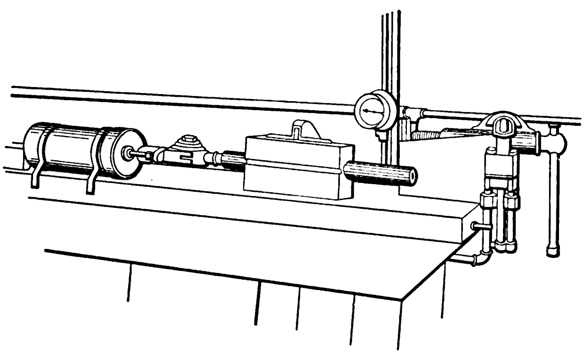
$$W = \frac{F \times a}{b}$$
$$F = \frac{W \times b}{a}$$
$$a = \frac{W \times b}{F} \text{ OR } a = \frac{W \times d}{W - F}$$
$$b = \frac{F \times a}{W} \text{ OR } b = \frac{F \times d}{W - F}$$

DELIVERED FORCES BETWEEN FULCRUM AND APPLIED FORCE

Study of braking pressures, Hartford.

effort for the service. A braking effort of 100 per cent. is held to be permissible for steel wheels, but no more than 90 per cent. is used for cast-iron wheels in order to limit flat spots.

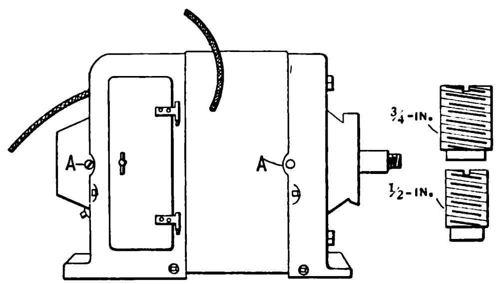
Rusting of Air-hose Nipples.—Previous to 1911, the Brooklyn Rapid Transit System experienced much trouble from the rusting of air-hose nipples at the entering ends. Formerly, these nipples were pushed into the pipes by hand, with the frequent consequence that the hose was injured even before it was placed in service. The oxidation of the hose also caused the cutting of the rubber by flakes of rust and by the jagged edges of the nipple. Sometimes the nipple would drop out on account of the reduction in diameter due to rusting. The company has succeeded in minimizing these undesirable conditions by inserting the nipples



Preventing rusting of air-hose nipples by inserting them pneumatically, Brooklyn.

pneumatically and by providing the entering end of the nipple with a brass ferrule. The device for installing the nipples is shown in an accompanying sketch. The power is furnished by means of a home-made cylinder composed of a piece of 6-in. pipe, which was bored and packed like a regular brake cylinder. The piece of hose into which the nipple is to be inserted is placed in a grooved block in line with the piston of the cylinder. The hose is clamped tightly by pressing upon it an upper grooved block which is hinged to the lower one and operated by means of a pedal. In addition to holding the hose in this manner, it is prevented from slipping by facing the grooves with rough pieces of old hose lining. When using this apparatus the operator lines up the hose with the ferruled nipple which is attached to the cylinder piston, presses the pedal to clamp the hose in the aperture formed by the blocks and then admits air to the cylinder to operate the piston. This device enables a man to insert 150 non-rusting nipples a day, or about three times the speed which was possible by hand.

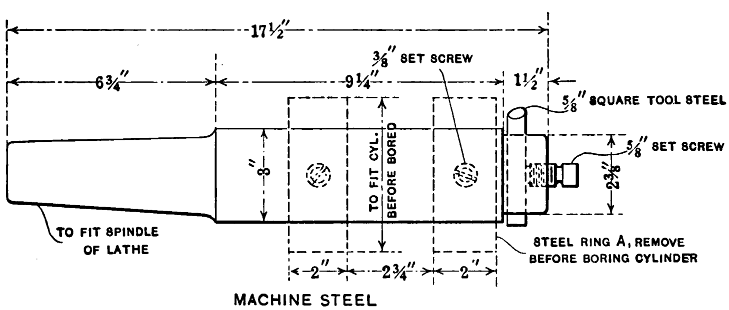
Tightening Compressor Motor Bearings (By George M. Coleman).—On the D-2 Westinghouse compressor motors the set screws "A" which hold the bearing in place become loose, thus giving the bearing a chance to vibrate. In time this vibration will cause much noise and trouble. These set screws are 1/2 in. in diameter by 2 in. long. Only half of the hole in the motor frame is tapped out. The upper half is drilled out



Tightening a compressor motor bearing.

5/8 in. When the bearings need tightening tap the upper half for a 3/4-in. screw. Cut the original set screw in two and slot the top, as shown in the sketch. A 3/4-in. screw with a small projection at one end is then made. Put the 1/2-in. set screw into place and then screw the 3/4-in. screw tightly against it. This will make a perfectly secure construction.

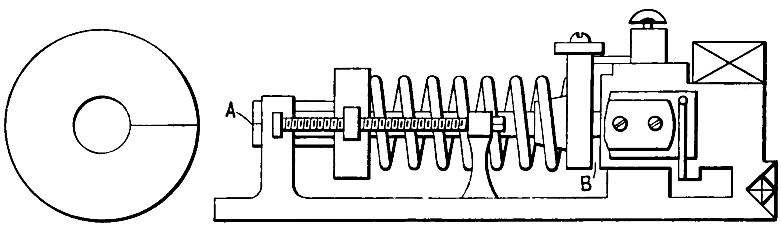
Rebushing Air-compressor Cylinders at Richmond.—The accompanying drawing shows a simple tool holder for boring out air-compressor cylinders on the axle lathe, as developed at the Richmond shops of the Virginia Railway & Power Company. This tool holder fits in the spindle of the lathe with a 5/8-in. square tool held in the end with a set screw. To rebore and bush the air-compressor cylinders the following process is carried out:



Tool holder for boring air-compressor cylinders, Richmond.

Strip the compressor of everything except the cylinders and frame, remove the tool holder and the upper carriage from the lathe, place the special tool holder in the spindle of the lathe with the steel rings marked *A* over the holder. Then place the cylinders on the lathe carriage upside down with the bore of cylinder in line with the lathe spindle and run the carriage forward until the bore of either cylinder fits over the steel rings *A*. Now shim up between the compressor frame and the carriage of the lathe, then bolt down. The cylinder should now be in perfect line with the lathe spindle. Run the carriage back and remove the steel rings *A* from the tool holder.

All bushings are turned to a standard size and cut 3/8 in. shorter than the air-compressor cylinders to allow a shoulder in the back end for the bushing to fit against. The bushings are pulled in the cylinder while chucked in the lathe with a bolt and clamp. Should the piston fit too tightly in the bushing it is skimmed out while the cylinder remains chucked in the lathe. This method of boring and rebushing air compressors gives a perfect job, besides permitting the work to be done in one-third of the time which was formerly required.



Adjusting attachment for Westinghouse electric pump governor.

Adjusting Westinghouse Electric Pump Governor (By Geo. H. Coleman).—When the adjusting attachment is not used with the Westinghouse electric pump governor, type G-1-A, it is regulated with difficulty. Those using this type have found that when the governor is set to cut out at 90 lb. it will not cut in again until the air pressure has been reduced to about 68 lb., making a variation of 22 lb. When the air is thus reduced the brakes give poor service. On the magnetic type the piston is held by the magnetic coil and spring. Consequently, when the pressure against the piston is sufficient to overcome the magnet and spring the armature begins to move away from the magnet. As the power of the magnet decreases faster than the tension of the spring increases, the rate of movement of the piston and armature increases more and more rapidly until the current is broken at the contacts. Then the electromagnet loses all its power, and the entire load is thrown upon the spring. As a result the armature and circuit closer are forced away from the magnet and contacts with a quick movement.

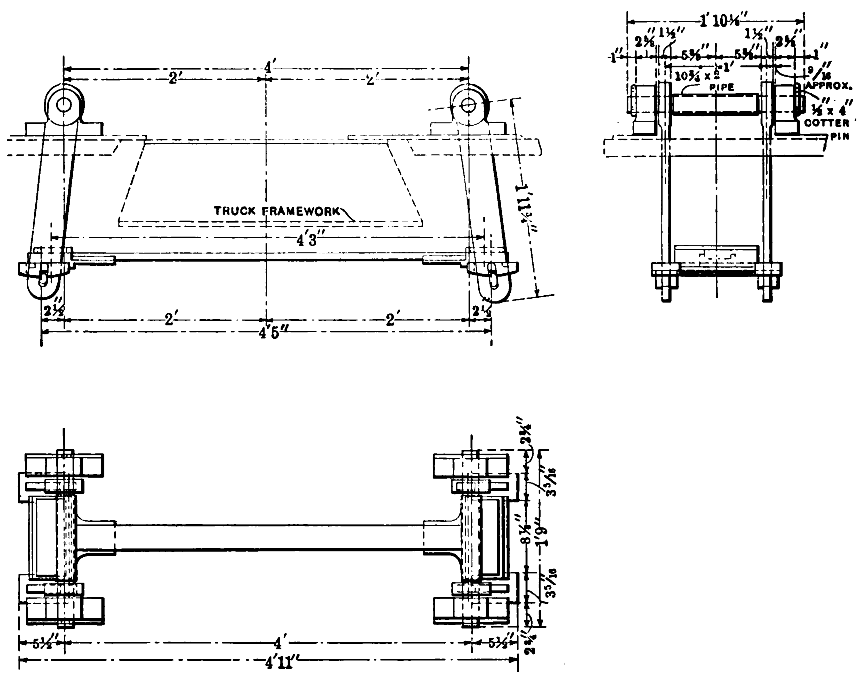
To correct this fault use a piece of cardboard about 3 in. in diameter, with a hole cut in the center large enough to admit the shaft. Cut the cardboard as shown in illustration, so that when the armature and circuit closer are released from the magnet it can easily be placed at "*B*" without taking the governor apart. Put a little shellac on the cardboard and it will hold firmly to the armature. This will make a magnetic gap the same width as the thickness of the cardboard, so that the variation will be between 10-lb. and 15-lb. air pressure.

Clasp Brake Rigging on New York, Westchester & Boston Railway.—Each of the motor trucks on cars of the New York, Westchester & Boston Railway, New York, is fitted with eight brakeshoes, two shoes being applied to each wheel. The purpose of this clasp brake design is to reduce the pressure per brakeshoe to reasonable limits when an emergency application of the air brake is made. It also minimizes the heating effect on the brakeshoes, as the regular schedule in which these cars are used involves frequent station stops from high speeds. A short brake rod with a clevis and roller connects the cylinder lever to a radius bar. The latter is supported at each end by rocking levers which tend to move by gravity into a position to release the brakeshoes when the pull from the air brake cylinder is released. From each end of the radius bar a rod extends toward the transoms and is attached in the center of a short horizontal floating lever. The inner end of this lever is fastened to the top of a live brake lever, carrying a shoe bearing on the inside of one wheel. A pair of rods straddling the wheel connect the bottom of this live lever to the bottom of the dead lever which is hung from the truck end frame. Means are provided for adjusting the length of these bottom connections as the shoes and wheels wear. The outer end of the horizontal floating lever is connected by a rod to the end of a centrally-pivoted lever of the same length on the other side of the bolster. The inner end of this pivoted lever is fastened to the live brake lever of the other wheel. The arrangement of levers on each side of the truck is the same, but the two sides operate independently of each other except for the single connection through the radius bar. The trailer truck brakes are of the inside-hung type with a top brake beam connecting the two live levers. The braking pressure applied on the trailer truck wheels being much less than that applied on the motor truck wheels makes four brakeshoes sufficient.

IV

TRUCKS, WHEELS AND AXLES

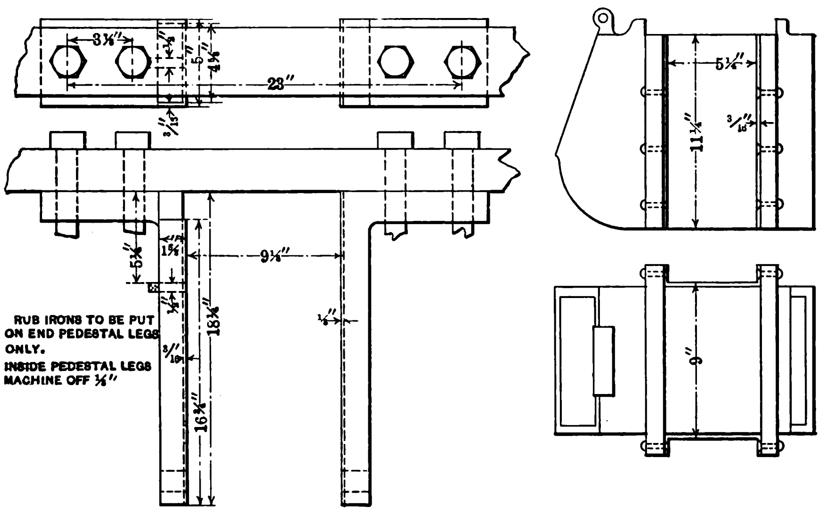
New Design of Swing Link.—The frequency of road troubles caused by broken swing links has been greatly reduced since the Decatur shop forces of the Illinois Traction System designed the links with a new bottom fastening and placed these links on all trucks as they were brought into the shops for general repairs. An accompanying illustration shows the design of the new swing link. The chief feature of interest in this link



Detail of swing link and spring seat, Illinois Traction System.

is its method of fastening, which permits of ease of replacement. When it was necessary to repair the old type of swing link, much time was usually lost in loosening the nut on the connection beneath the spring plank, and very frequently these nuts had to be split. In the new form of link the two are connected by a piece of iron so shaped that it fits into slots cut in the lower ends of the link and is held in place by means of a gib and cotters. Square shoulders on either side of the spring link provide for handling the heavy stresses. Since the new form of link was put into effect none has broken and the time of making repairs when necessary in general overhauling has been considerably reduced. The connecting bar between the two links of the new type may be removed by first jacking up the spring plank until the weight is released from the link, then removing the gib.

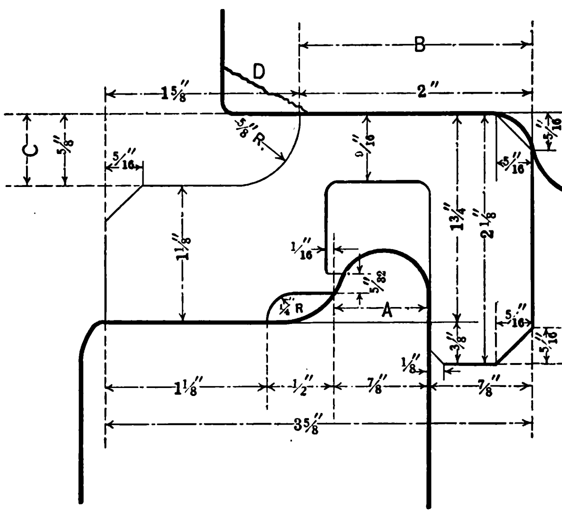
To remove excess stresses from the running gear when the cars enter curves at high speed, a change has been made in the angularity of the swing links. They are now set a little farther away from vertical and thus the cars adjust themselves a little more readily to sharp curves. This change in the pitch of the swing link and the new type of links are applied as fast as cars are brought into the Decatur shops for repairs. The cost of new links which are made in the company's shops is $4 per set.



Rub-irons for journal boxes and pedestal legs, Lackawanna and Wyoming Valley Railway.

Rub-irons for Journal Boxes and Pedestals.—On the Lackawanna & Wyoming Valley Railway, Scranton, Pa., the journal boxes and pedestals are furnished with wearing shoes or rub-irons, to prevent the excessive play of the brake rigging which had been caused by the wear of the pedestals and boxes. Instead of buying new boxes the old ones were planed and wearing shoes were riveted to them as shown in an accompanying engraving. This engraving also shows the application of the shoes to a pedestal. As the brakes are inside-hung, the wearing shoes are put on the outer or end pedestal legs only. There is a bushed tie bolt in the bottom hole of the pedestal to hold the bottom, while the upper end is held by a 1/2-in. countersunk bolt which brings the head flush with the shoe. All wearing shoes are 3/16 in. thick.

Hartford Wheel Gage.—The wheel limit gage developed in the Hartford shops of the Connecticut Company is of hardened tool steel 1/16 in. thick, shaped as shown in the accompanying drawing. When a wheel is in such condition that the gage will set on the wheel, as per *A* on the drawing, the wheel is taken out and turned. If taken out at this time, the turning does not decrease the diameter of the wheel more than 3/8 in. The section of the gage marked *B* is used for gaging broken treads on cast-iron wheels. When the tread is chipped as far as the point *D* the

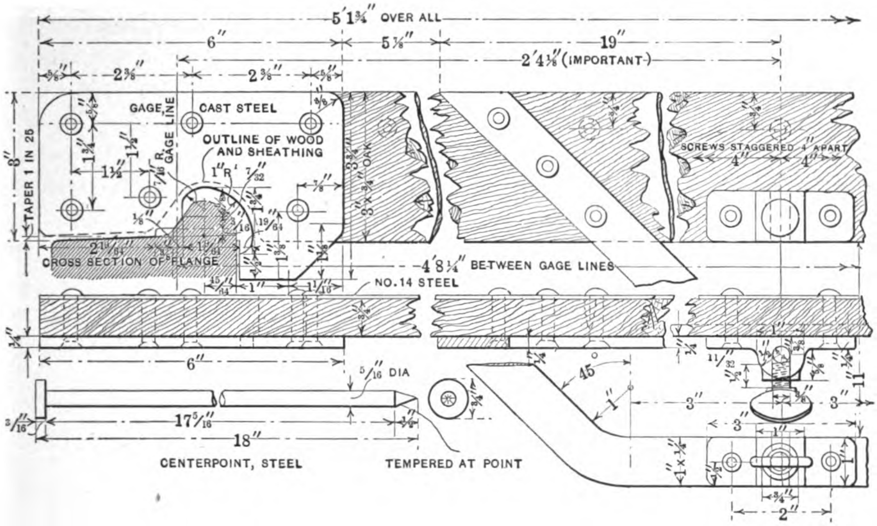


Wheel gage, Hartford.

wheel is condemned. The limit *C* is for chipped or worn flanges. When the flanges reach *C* they are not permitted to run under interurban cars, but they are still available for city service, subject, of course, to frequent inspection.

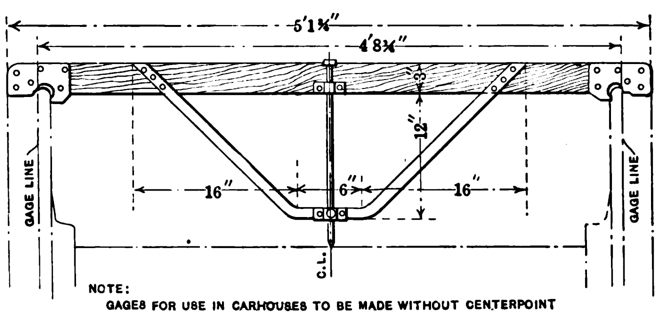
A Twofold Wheel Gage.—The drawings present on page 41 the detailed design and assembly of a wheel gage which has been used by the Bay State Street Railway, Boston, for the past few years. One drawing shows how the wheels are mounted from the gage line and also equidistant from the center of the journals by means of a pointer placed at the punch mark in the center of the axle. The maintenance of an equal distance between the center of the axle and the gage lines of the wheels has proved an important factor in the reduction of flange wear.

The gage is made up of seasoned ash with No. 14 steel plate on one side and a 1/4-in. thick steel plate on the other. The latter plate is machined out to rest only on the tread and contour of the wheel at the gage line and against the back of flange, allowing merely enough clearance to take care of the tolerance variation of the wheel. The pointer placed



Details of Bay State twofold wheel gage.

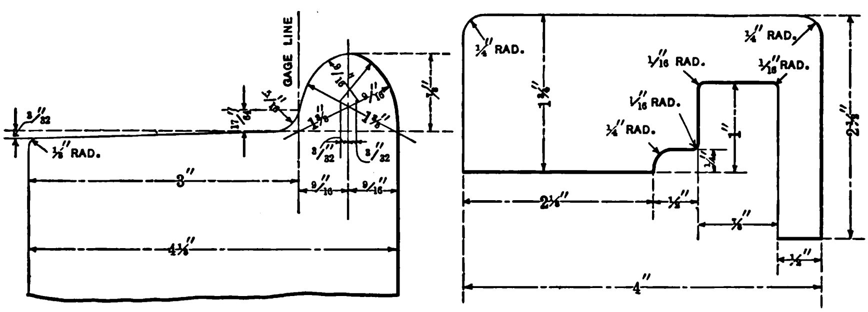
at the center has a 3/8-in.×1/2-in. thumb screw at its lower support to make adjustments for differences in the diameter of the wheels. The gages used in the carhouses are made without the center point. E. W. Holst, superintendent of equipment of the company, states that this gage



Bay State twofold wheel gage complete.

enables the man at the wheel press to insure in very little time the accurate mounting of the wheels relative to the center of the axle and to the gage line of the wheels.

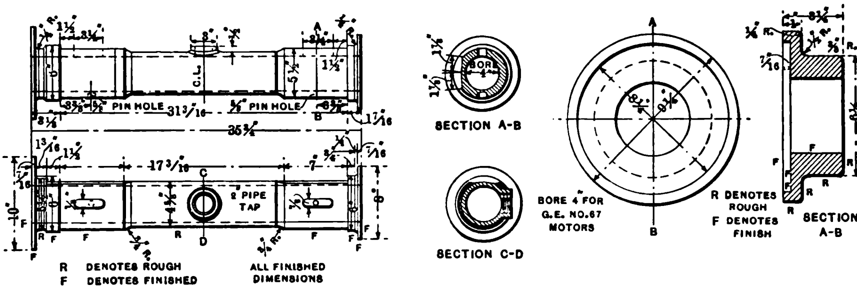
Indianapolis Wheel Practice and Gages.—The Indianapolis Traction & Terminal Company was among the first electric roads to use steel wheels and steel-tired wheels, but beginning in 1910 the steel-tired wheels have been gradually eliminated. The forged steel wheels used under interurban cars are 34 in. and 38 in. in diameter and have rims 3 1/4 in. thick with a contour as shown in the accompanying engraving. The tread of this wheel is 3 in. wide and the flange 1 1/8 in. thick from gage line to the back of the wheel. The flange is 7/8 in. deep. It is the practice to wear and turn the rims down to a thickness of 5/8 in. The wheels in service are inspected with a limit gage made from case-hardened steel 1/4 in. thick. It is so shaped that its position is fixed by the back of the wheel and the flat of the tread. It will fit over a flange that has a thickness no greater than 7/8 in. on a line 1/4 in. above the projected line of the tread. When a wheel has reached this limit of wear it is taken out of service and about 5/16 in. of metal is turned off the tread in order to reshape the flange. The wheel inspectors pay especial attention to ordering wheels in for re-turning at the point in their life when the flange can be reshaped with the least practicable loss of metal on the tread.



Contour of steel wheel flange and tread, also limit of wheel wear gage, Indianapolis.

Axle-bearing Sleeves.—The drawings on page 43 show the standard forms and dimensions of the brass axle sleeves and shrunk-on cast-iron axle collars used with the GE-67 motor equipments of the Georgia Railway & Electric Company. Similar sleeves and collars are in use with the Atlanta company's other motors. The use of axle-bearing sleeves involves a somewhat higher first cost than ordinary axle bearings, but this is more than balanced by the reduction in maintenance. The gears and pinions continue to stay in better mesh than when the bearing weight is concentrated at two points. As the sleeved axle penetrates the gear case for 1 1/2 in. there is no trouble from grit or dirt. The sleeves are made of scrap metal with enough new metal to work them properly.

Brooklyn Wheel Practice and Gages.—On the Brooklyn Rapid Transit System, the ultimate rejection of worn wheels lies with one specialist. All that the foremen are expected to do is to see that the wheels are worn to but not below the scrapping dimensions which are specified by the superintendent of equipment and that flanges are worn in accordance with limit gages. The Eastern Division elevated shops



Detail of brass axle sleeve for GE-67 motor and cast-iron axle collar used with sleeve, Atlanta.

are used for all wheel, axle and gear work. Before sending wheels to these shops the local foremen are instructed to see that the wheels have been worn to the specified scrapping diameters as given in Table I for the elevated and surface divisions respectively.

TABLE. I.—SCRAPPING DIAMETERS OF STEEL WHEELS

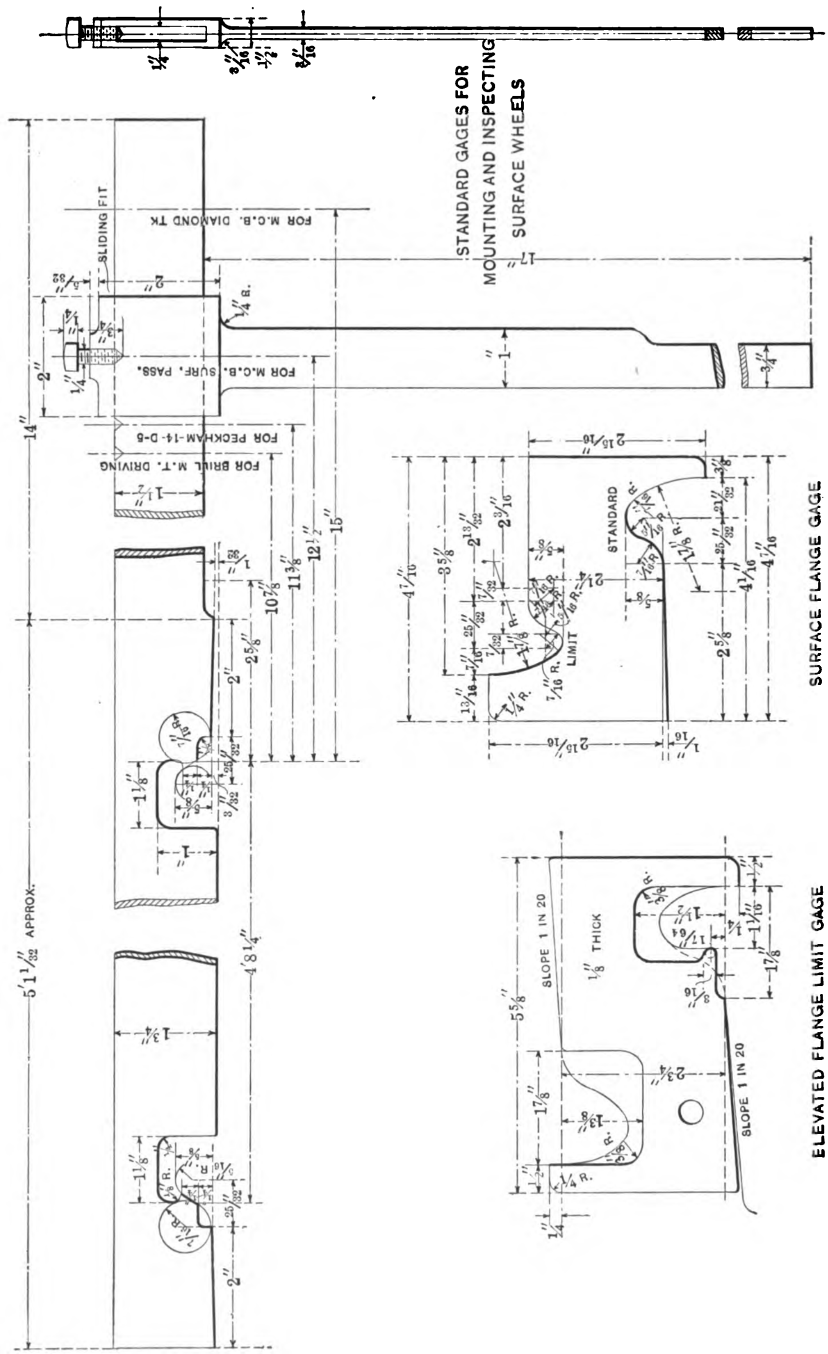
ELEVATED DIVISION

Description of Wheels	Scrapping Diameter
33-in. steel-tired wheels	30 in.
30-in. steel-tired wheels	27 in.
34½-in. solid steel motor-truck wheels (7½-in. rough bore, used under Type 1400 cars only)	31 in.
34-in. solid steel motor-truck wheels (6⅛-in. rough bore)	30 in.
34-in. solid steel trailing truck wheels (5¾-in. rough bore)	29½ in.
31-in. solid steel trailing truck wheels	26½ in.

Wheels under trailing trucks of Type 1400 elevated motor cars, which operate in Rockaway Beach service during summer months, are removed from these trucks when they reach 29 in. diameter and are used under other cars until they reach 26½ in. diameter.

SURFACE DIVISION

Description of Wheels	Scrapping Diameter
33-in. solid wheels (service car)	28½ in.
31-in. solid steel wheels (service car)	28½ in.
31-in. steel-tired wheels (service car)	29 in.
33-in. solid steel wheels, which had 3-in. rims (passenger cars)	28½ in.
33-in. solid steel wheels, which had 2½-in. rims (passenger cars)	29 in.
34-in. solid steel wheels, single and maximum traction truck drivers	30 in.
21-in. solid steel wheels (pony)	19 in.
21-in. solid steel wheels (pony), new design, with additional metal placed on inside of wheel under rim	18½ in.



Three styles of gages for wheel work, Brooklyn

In reference to Table I it should be stated that a special pony wheel with a deep-dished web was necessary on account of interferences with the journal boxes on some old side-bearing maximum traction trucks.

When the wheels are received from the maintenance shops they are carefully checked with gages for defects and dimensions by the special inspector to determine whether they can be returned to service without any attention in the wheel shop. If any work is found necessary or if the wheel or axle has reached the scrapping limit, the inspector so indicates. The same man also examines the finished wheels and axles before they leave the wheel shops to see that they are in accordance with the company's standards. Both wheels of a pair must be within 1/32 in. of same diameter. The standard inside-gage measurement to which all elevated wheels must be pressed is 4 ft. 5 3/8 in. Wheels are considered out of gage if they are less than 4 ft. 5 1/4 in. or more than 4 ft. 5 1/2 in. The accompanying drawings are presented of the various types of gages used. Some of these, of course, are also furnished to the outside shops to guide them in returning wheels. One of the diagrams on page 44 shows the flange limit gage of the elevated division and the flange gage for surface rolled wheels, as well as the standard gages for mounting and inspecting wheels on surface trucks of Brill maximum traction, Peckham 14-D-5, M.C.B. passenger and M.C.B. diamond-frame freight trucks.

Wheel Changing at Mobile.—S. M. Coffin, master mechanic of the Mobile (Ala.) Light & Railroad Company, dispenses with the usual pit or car-jacking methods of changing wheel pairs in trucks. A car requiring attention of this kind is run up an inclined track until the truck rests on a removable section of track which is kept in place by an air hoist. As soon as the wheel and axle set is unbolted, it is lowered to the floor by means of the hoist and taken to the machine shop. *Vice versa*, the replacing set is rolled into the removable section of track when the latter is flush with the floor and then raised into the side frames of the trucks. This method was very economical to install as the trestle was built up of old rails, brakebeams, turn-buckles, etc., and the pit itself did not require much work as it had to be of little greater depth than the rails. Mr. Coffin states that with wheels fitted on the axles two men usually can change a pair of wheels in an hour but the record time for this work is 36 minutes. If it is desired to put the same axle back into the car when changing, three men can bore, fit and make the complete change in two and a half hours.

V

CLEANSING BY DIPPING OR SAND-BLASTING, CAR WASHING, PAINTING AND GLAZING

Caustic-soda Baths for Trucks and Motors.—Among the interesting practices of the shops of the Hamburg (Germany) Rapid Transit System is the dipping of trucks and motor shells in caustic-soda solution. Thus a complete truck frame minus the journal boxes is brought by a crane for dipping into a cleaning tank containing a solution steam-heated to a temperature of 100 deg. C. Ordinarily a steel, cement-covered sliding door completely closes this compartment at the floor line, but the top is left open to permit ingress and egress for the objects brought to the tanks. By this arrangement no dirty water can bespatter the main shop. A smaller caustic-soda tank is provided opposite the larger tank for the dipping of motor shells. The use of a hot caustic-soda solution has proved very effective for the thorough and quick cleansing of metal parts.

Sand-blasting at San Francisco.—At the shops of the United Railroads of San Francisco practically all apparatus for repair is exposed to a sand blast before being welded or undergoing any other repairs. The process is very simple and quick and rapidly cleans the grease and dirt from the part and makes the application of the welding process or other repair a simple matter. The sand-blast is used even on such parts as commutator and the boards of controllers and thoroughly cleans the metal parts without affecting the insulation. Trucks also are sand-blasted when brought into the truck shop for overhauling. This not only removes all grease, dirt, old paint, etc., but it also gives a clean surface of metal so that it is easy for an inspector to see whether there are any mechanical defects in the truck which need attention.

Car Cleaning in Denver.—The cars of the Denver City Tramway are each supplied with an ordinary cornstraw, four-sewed house broom, weighing 24 lb. to the dozen. As opportunity offers, conductors do some sweeping out of cars at the end of the line, during the time of service, and each conductor is supplied with a Canton-flannel wiping cloth (12 in. $\times$ 24 in. in size) and does some dusting. Every day each car, whether out on a long or a short run, is swept out by the conductor before it is put back in the carhouse. In addition to this daily sweeping, one cleaner at each carhouse does nothing but sweep out cars, after having lightly sprinkled them. He sweeps an average of forty-five cars per night of ten hours.

On the basis of the average maximum cars operated daily, 278, a car is well swept every one and a half days.

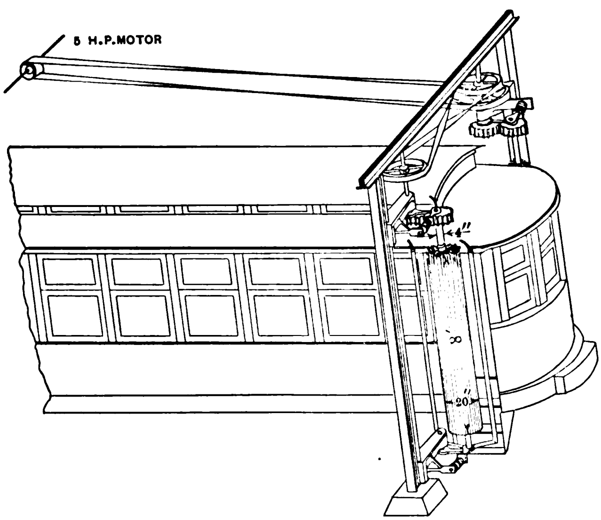
In addition to this, the cars are dry-cleaned with cheese-cloth, Canton-flannel or white waste saturated with a polishing oil, the men going over the exterior and interior of the car, collecting the dust and dirt and giving the surface a fairly well-polished appearance. This includes all of the interior down to the mopboard and all of the exterior of the car. The mopboard is cleaned by the use of a cleaning soap which is diluted in water. Each cleaner has a pail of diluted soap or suds and uses it frequently on other parts of the car besides the mopboard, but if used on a varnished surface it is immediately washed off and followed by the oiled polisher. On the basis of maximum cars operated every car is cleaned once in 2.6 days.

No water whatever is used in the car-cleaning work except from the pails mentioned, by means of a wet rag, and after storms, when mud is washed from the outside of cars by a hose. For cleaning glass the method has been to use dry whiting. With the exception of cars which may be shopped for repairs and out of service, all cars are disinfected daily with "formalin." This is used in a small tin spray gun, and the operator goes over the entire car floor under and around the seats.

During the time of working cars through the paint shop, which is on a basis of every eleven months, after the car is stripped of all sash and trimmings the interior and exterior are thoroughly scrubbed with a strong solution of old-fashioned soft soap.

Instantaneous Electric Water Heater for Car Washing at Cincinnati.—Home-made water-heating devices of many descriptions have been employed in the car-washing departments of street and interurban railways and have usually involved the combination of a heater and a hot-water storage tank. Such a plant, however, was not considered practicable by the mechanical department of the Cincinnati Traction Company owing to several controlling factors imposed by local conditions. Hot water was desired throughout the year, and therefore it could not be furnished by the steam-heating plant. Again, car washing was done in one end of the paint shop bay, so that a coal heater could not be employed unless it was installed at some outside point, and, finally, it was desirable to have hot water at a pressure, a condition which could not be obtained continuously with an ordinary coal-type heater with a tank. With these limits in mind a home-made electric water heater was designed and installed. Although the cost of heating water electrically was greater than by other methods, the device met all the requirements, and the quantity of current used was so small as not to make the cost prohibitive. For all practical purposes this home-made water heater is instantaneous. It consists of a box 8 ft. long by 2 ft.

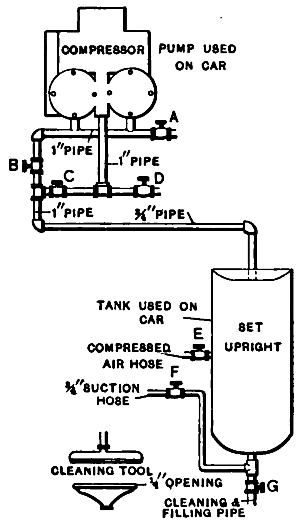
square in section, built of 1 1/4-in. yellow pine. The box is lined with 1/4-in. transit board to insulate the wood from the heater coils. Eight 17-amp. electric-coil heaters are installed on the bottom and sides of the box, arranged in two circuits, with four heaters in each. These are supplied with energy through a direct connection to the 550-volt trolley by way of a knife switch, and they are sufficient to maintain a temperature of 210 deg. in the box. The heater coils on the bottom of the box serve as supports for the 1-in. wrought-iron pipe coils which are arranged in a rack four coils high and six coils wide. These pipes form a continuous coil which is connected with the city water supply at one end and to a hose connection at the other. When the valves provided at each end of the coil are open, cold water flows through and the heat maintained in the box by the electric heaters is sufficient to raise the temperature of the water to a point suitable for car washing before it reaches the hose connection. In actual service this heater has been found of ample capacity to supply four scrubbers with all the hot water they can use in a ten-hour day.



Motor-driven car-washing device, Seattle.

Motor-driven Car-washing Device.—The accompanying illustration shows the general arrangement of a car-washing device invented by A. D. Campbell, master mechanic Seattle division Puget Sound Traction, Light & Power Company, and in use at the Georgetown shops of that organization. The device consists of a cylindrical brush 20 in. in diameter and 8 ft. high, mounted upon a vertical axis and driven in a wooden frame of adjustable design by a 5-h.p., 550-volt d.c. motor located on the top of the frame. The framing is made up of 4-in.$\times$7-in. and 6-in. square timbers and can easily be installed between any two tracks of a car-washing floor. Water is supplied at the top of the brush by a 1 1/2-in. pipe connected at its lower end with a valve and hose coupling. The motor starter and switch are located upon a post at the side of the washing device. Cars are washed by running them slowly past the rotating brush, which provides effective cleaning on the exterior of the body in much shorter time than is possible by hand and with nominal expense. The original design of the device provides for the use of a double set of brushes driven by a single motor of the size above stated so that each side of the car can be cleaned at the same time. The device is easily taken down and can be readily erected in other locations.

Combined Suction and Pressure Apparatus for Car Cleaning (By C. H. Copley).—The writer has been using for some time, at the Norwalk division shops of the Connecticut Company, a combination vacuum and pressure car-cleaning outfit, the design of which may be of interest to others who have a compressor available. The piping connections which are shown in the accompanying sketch are manipulated as follows:



Combined suction and pressure apparatus for car cleaning.

To use as a vacuum or seat cleaner, close *A* and *C* and open the valves *B* and *F*. About two pails of water are used in the tank to prevent the entrance of dirt and dust into the pump. Upon starting the machine with the valves set as above, close the tank connections *E* and *F* and open *G*, upon which the water will be sucked into the tank. Close *G* after the water is in the tank and then with the suction hose hitched on at *F* open *F* and the apparatus is ready for service. It is desirable to change the water for every third car. To clean the tank stop the machine and open *F* and *G*, whereupon the dirt and water will run out.

To use this equipment for the compressed-air cleaning of controllers, motor shells, armatures, etc., close valves *D* and *B*, open valves *C* and *A*, close the tank valves *F* and *G*, attach hose to *E* and open ready for service.

In this way a 20-ft. closed car can be thoroughly cleaned in 15 minutes and a 33-ft. car in 30 minutes.

Disappearing Scaffold for Washing Cars—Heating Water for Car Washing.—The mechanical department of the Chicago, South Bend & Northern Indiana Railway installed in 1912 an ingenious disappearing scaffold in its shops at South Bend, Ind. The scaffold support consists of two sections. One is a 3-in. cast-iron flanged pipe, 7 ft. long, buried underground with the flange flush with the floor. Inserted in this 3-in. pipe is a 6-ft. section of 2 1/2-in. wrought-iron pipe, provided with a cap and handle for raising or lowering. The 2 1/2-in. pipes which form the legs of the scaffold are spaced on 11-ft. centers and are provided with slots for inserting a removable bracket made of 3/4-in. round iron. The lower portions of these pipes are also provided with holes drilled on 6-in. centers to permit the insertion of the 3/4-in. pins which support the scaffold at the desired working elevation. These pins are attached to the flanges of the 3-in. pipe by chains to prevent their being mislaid. The advantages of a scaffold support of this character are evident, in that it can be lowered to the floor level out of the way of any other work which it may be necessary to do beside a car, and yet is of a substantial, permanent construction.

In connection with the disappearing wash scaffold a very interesting and inexpensive installation has been made for heating the water used to wash the cars. This installation consists of an ordinary 12-barrel galvanized water tank supported on the lower cords of the roof trusses. This tank is supplied by water from the city water mains and the water supply is controlled by a floating automatic valve arrangement, similar to that used in a flush tank. The water in the tank is kept at about the boiling temperature by six 6-ft. sections of 1-in. pipe, supplied with steam from the high-pressure heating plant. C. E. Atkinson, master mechanic for the South Bend company, who is responsible for both the wash scaffold and water-heating installations, is of the opinion that much better results can be obtained by washing cars with hot water than with cold, in that it reduces the quantity of soap required and labor necessary to get a first-class job.

A Power-driven Car Cleaner.—The following detailed particulars on cleaning the sides of steel cars with a motor-driven car cleaner have been furnished by P. V. See, superintendent car equipment, Hudson & Manhattan Railroad, Jersey City, N. J. The device consists of an electric drill to which a circular brush is attached, the whole being operated noiselessly through speed-reduction gearing at 1350 r.p.m. by a 110-volt, 25-cycle motor. The original drive was pneumatic, but this was found to be too noisy and inconvenient on account of the dragging hose. It was also rather expensive in maintenance and air consumption. In fact, the cost of energy for air consumption was about 50 cents a day compared with 2 cents a day for straight electric drive. The brush is of the ordinary round window-cleaning type used for manual car cleaning with a bristle holder of about 5 1/2-in. diameter, but the original bristles are replaced by stiffer ones. One brush will serve to clean the exteriors of about twelve 48-ft. all-steel cars. After this the brushes are still used by the men to spread the emulsion by hand before it is worked up by means of the machine. The brush is not operated at the high speed hereinbefore noted because when pressure is applied to the brush its speed is greatly reduced. The entire mechanism weighs only 6 1/4 lb., and as the trailing wire is very light a workman can use it steadily all day long without feeling any undue fatigue. The revolving brush has been found especially effective in working around rivets.

This brush is used in connection with a car-cleaning emulsion as follows: First, one of the two men per car spreads the material by hand over various parts of the exterior with a worn brush; then the revolving brush is used for the cleaning and polishing; next the sides are wiped down with dry waste, and finally the outside panes of the windows are cleaned.

The method of paying for cleaning car exteriors in this way is also of interest. Two men always work together, taking turns in handling the motor brush. The reason for including outside window cleaning by the same men is to make them exercise more care in preventing the spattering of the emulsion. This policy has eliminated complaints from the regular window cleaners, who had asserted that their work was ruined by the carelessness of the emulsion users. With the aid of the electrically operated brush two men clean the exteriors of three cars in an eight-hour day, at an average labor cost of $1.07 per car, compared with a cost of $1.75 when the work was done by hand at the rate of two cars a day with a two-man gang. This payment is based on the bonus rate system which is used in these shops for all work except the straight window cleaning, which is on a piece-work basis. The bonus rate for this operation is $1.20 per car. The hour rate of each of the two men is 17 1/2 cents, so that the labor cost of turning out the three cars in eight hours is $2.80. At the bonus rate of $1.20 per car, however, this cost would be $3.60. The company therefore divides evenly with the men the difference between $3.60 and $2.80, so that each cleaner earns 20 cents extra a day. The cost of the material averages about 50 3/4 cents per car, based upon the use of 1 1/3 lb. of waste and 2/3 gal. of the emulsion. Motor-brush cleaning is done once a month. In addition, however, arrangements are made to dry-wipe the cars twice a month in view of the tendency of the emulsion to catch particles of dust. The dry-wiping is done by two men who go over the cars at the terminals. Such cleaning takes about half an hour and costs about 30 cents per car.

Car Washing Versus Paint Preservation (By Morgan B. Smith).—In the latter part of November, 1912, E. J. Burdick, superintendent of power of the Detroit United Lines, made a trip to one of the suburban car-washing stations of his company for the purpose of noting the methods used in washing the large interurban cars running on that division. He was particularly interested in finding out the reasons for the failure of the paint and varnish on one of the cars after only three months' service after it was refinished.

The results of this observation of methods at one car-washing station led to a very complete investigation of the methods employed at the other stations, about twenty in number. This general investigation proved beyond any doubt that the washing of cars plays a large part in the life of the paint and varnish with which the cars are finished.

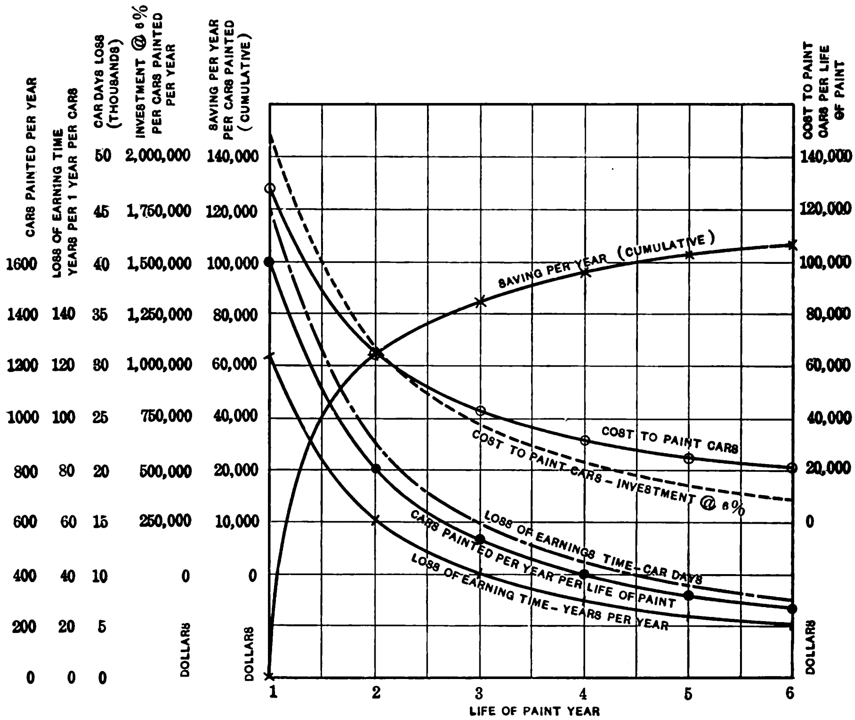


Diagram showing statistics of painting cars, Detroit.

In order to indicate in a general way the importance of long life of car finish some computations were made on the basis of 1600 cars in service (a low figure) at a cost of $80 each for refinishing (also a low figure). These calculations are shown in Table I.

Not only is there the direct cost of preparing the car for refinishing and the subsequent refinishing; there is also the much greater factor, namely, the loss of earning time while the cars are out of service in the paint shop.

Assuming that it requires four weeks properly to refinish each car, we arrive at the figures given in Table II, which show the actual loss of earning time in car days per year and in years per year.

TABLE I.—POSSIBILITIES OF ECONOMIES

Life of paint, years	No. cars painted per year	Cost to paint cars	Saving in cost of painting (Cumulative)	Cost to paint cars represents an investment of (at 6 per cent.)
1	1600	$128,000	....	$2,133,333
2	800	64,000	$64,000	1,066,666
3	534	42,720	85,280	712,000
4	400	32,000	96,000	533,333
5	320	25,600	102,400	426,666
6	267	21,360	106,640	356,000

TABLE II.—ACTUAL LOSS OF EARNING TIME

Life of paint, years	Cars painted per year	Loss of earning time per year	
		Years per year	Car days per year
1	1600	123.1	44,800
2	800	61.5	22,400
3	534	41.0	14,952
4	400	30.0	11,200
5	320	24.6	8,960
6	267	20.5	7,476

As the result of this investigation the company determined to turn the matter over to the laboratory for thorough research there under the direction of the writer of this article.

The results of the laboratory research may be summarized thus:

Criticism of Old Methods.—1. Water at too high a temperature is used.

2. Too much soap is used.

3. The period of contact of soap with the highly finished surfaces is too long, *i.e.*, rinsing does not follow soon enough after the application of the soap.

4. The use of soda ash cannot be too highly condemned.

5. There is insufficient wetting of the car surfaces to soften hard mud and dust and to loosen sand, etc.

6. Soap is used which undoubtedly attacks the varnish and paint.

Investigation of Methods Criticized.—1. Reference to builders of motor cars and other highly finished vehicles, followed by exhaustive laboratory tests, showed that the maximum safe temperature for wash water is 80 deg. Fahr.

2. The use of too much soap may be avoided (and now is) by supplying the car-washing stations with a stock soap solution of a strength equivalent to 1.5 oz. per gallon of water. With stronger soaps this weight of soap may be reduced, but it should never be used on car surfaces at a greater strength than given above.

3. Rinsing must follow the soaping immediately to avoid attack by the soap on the car surfaces.

4. Soda ash or other equivalent alkali must be kept out of reach of the car washers. It is an excellent paint remover.

5. Cars must be wet down over the entire surfaces at least twice and, better, three times, to assure the softening of the accumulated mud and sandy particles.

6. Referring to paragraph one, above, we recommend that at each car-washing station there be installed a suitable recording thermometer in each of the supply tanks so that a record of the temperature of the wash water may be had for every hour of the day. We further recommend that the charts used be marked with red ink at the desired temperature (80 deg. Fahr.) so that the men in charge may see at a glance whether the temperature is correct or not.

6. The character of the soap used has a great deal to do with the life of the varnish and paint upon which it is used.

Analyses of Soaps.—In order to get some knowledge of the general run of the so-called potash oil soaps on the market, eleven soaps were purchased in the open market in the city of Detroit and analyzed. The results are shown in Table III.

TABLE III.—ANALYSES OF SOAPS, PERCENTAGES

Soap No.	1	2	3	4	5	6	7	8	9	10	11
Water	58.45	59.85	64.05	58.86	49.41	52.62	54.62	47.36	54.90	64.5	53.75
Free acid	0.17	0.51	0.40	0.43	0.17	0.23	0.51	0.28	0.56	0.43	1.07
Total alkali	5.88	5.54	4.45	5.31	5.53	6.65	6.31	6.69	5.44	5.23	6.28
Free alkali	0.06	0.08	0.07	0.05	1.84	0.08	0.06	0.11	0.94	0.10	0.085
Insoluble in water.	.....	0.03	0.03	0.05	0.02	0.01	0.02	0.01	0.01	0.01	trace
Fats (soap)	29.2	29.00	29.50	31.00	39.00	33.00	32.60	39.50	30.04	28.18	37.88
Undetermined (fillers), glycerine, etc.	6.24	4.99	1.51	4.31	4.04	7.81	5.89	6.05	8.13	1.53	0.935

Notice the free alkali in Nos. 5 and 9 and the free acid in No. 11.

These soaps were also used in so-called panel tests, which will be described below.

No soap was found which did not in time attack the varnish and paint on the test panels. As the result largely of the panel tests, recommendations were made as follows in the matter of first, second, third, fourth and fifth choice among the soaps tested for the given utility, namely, car washing. First choice, soap No. 3; second choice, soap No. 9; third choice, soap No. 4; fourth choice, soap No. 2; fifth choice, soap No. 10. It is to be noted that those soaps which had the least detrimental effect upon paint and varnish in the panel tests are those which contain medium amounts of actual soap, running from 28.18 per cent. to 31.00 per cent. fats (anhydrides).

Soap No. 5, above, contains a large percentage of free alkali and showed by far the worst attack on paint and varnish.

Panel Tests.—In the so-called panel tests sections of panels from trolley cars were subjected to the action of solutions of the soaps being tested. The panels were one-half immersed. The temperature was that of the laboratory, ranging from 20 deg. to 24 deg. C. The strength of the soap solutions in each case was equivalent to 10 grams per liter (1.33 oz. per gallon).

The panels were immersed in the soap solutions, left for a stated time, removed, rinsed with running water and brushed off with a soft long-haired brush. The condition of the paint and varnish was then noted.

The panel tests resulted as shown in Table IV, beginning with that soap which showed the least effect upon the paint and varnish:

TABLE IV.—RESULTS OF PANEL TESTS

Time: Soap No:	24 hours 2	48 hours 2	96 hours 4	120 hours 3	13 days 3	14 days 3
	3	3	3	4	9	9
	7–11	7–11	10	9	4	4
	4–10	4	6	10	1	2
	9	10	2	6	2	10
	5	9	9	1	10	1
	1	6	1	2	6	7
	6	5	7–11	7–11	8	6
	8	8	5	8	7–11	8

The panel tests are undoubtedly of great value in the final acceptance or rejection of soaps for car-washing purposes.

There was a very great divergence in the character of the soaps tested in the panel tests, there being a decided line of demarcation between the first five soaps and the remaining specimens.

All analyses were carried out in the manner recommended by the United States Department of Agriculture, Bureau of Chemistry, Bulletin No. 109, revised.

New Basis for Car Washing.—Upon completion of this very important research the matter of car washing was at once placed upon a new basis. A competent man, trained in practical handling of paints and varnishes, was placed in charge of this operation and is now held responsible for the work on the cars.

The new system has now been in operation in Detroit about twelve months and already the bettered conditions are evident. Not only is there less attack on the paint and varnish, the cars look better and brighter. They lack a certain dulled appearance which they formerly quickly assumed in the course of washing. The varnish retains its luster very markedly compared with its appearance under the old methods of car washing.

The company hopes to lengthen the life of the paint and varnish at least one year; it may be that an increase of two or three years is entirely within reach. Reference to the calculations given above shows what an important factor this is in the economies of car maintenance.

As in all work of this nature, experience will show what is most desirable and where improvements may be made in the recommendations advanced for the new car-washing methods.

The company believes it has located one of the "leaks" which have gone unnoticed heretofore in car handling, and it is giving this information to the railroad world in the hope that it may be of interest and value to those engaged in the operation and maintenance of cars in general.

Painter's Scaffold at San Francisco.—An interesting feature of the paint shop of the United Railroads of San Francisco is an adjustable painter's scaffold, which runs the entire length of the shops. The construction includes the use of permanent wooden posts, 4 in.×6 in. and spaced 13 ft. apart. They are set in concrete to a depth of 8 in. The adjustable rack with which each post is equipped, for holding the painters' boards, is simply a strap-iron bracket made up of 1 1/2-in.×3/4-in. iron, looped around the post and with an arm on its outer end on which the painters' boards rest. The angle at which this bracket hangs on the pole provides sufficient friction so that it will hold its position on the post under the weight of the painters. As it is simply looped around the post, its height, of course, may easily be adjusted.

Painting Fenders by Dipping.—At the Hartford shops of the Connecticut Company a simple yet effective means is used to paint fenders. They are not coated with a brush but are just dipped into about 2 in. to 3 in. of fender compound, which floats on top of the water in a wooden tank. The fenders are then set aside without any further attention and dry in from fifteen minutes to twenty minutes.

Painting Fenders and Trucks with an Air-brush.—At Toronto an economical method of painting fenders is to coat them with a tar varnish as sprayed from an air brush at 80 lb. to 90 lb. pressure. The fender is set up under a hood which is provided with air-blowing connections for drawing up the varnish vapors. The air brush enables two men to paint sixteen fenders an hour, as against three fenders painted by hand in the same time. The air painting is also superior to the old hand method as there is no tendency for the paint to gather in lumps. The varnish which gets by the grids is caught in catchpans, the contents of which are afterward removed for re-use. The same method has been applied to truck painting without using an exhaust hood. First the trucks are thoroughly scraped and cleaned with compressed air. By using the air brush, one man can coat a truck with a mineral quick-drying paint in one hour or about one-fourth the time required by hand.

A Paint Shop Kink in Drying Racks.—An improvement over the usual method of constructing drying racks for varnished sash frames is to use triangular strips on the sides instead of rectangular strips or trays. Only the lower corners of the side pieces of the sash frames come in contact with the supporting strips so that the varnished surfaces are not marred in any way. A considerable saving in the space required between the sashes is also effected and more frames can be placed in a rack of the same height. Canvas curtains should be used in front of the drying frames to keep out dust.

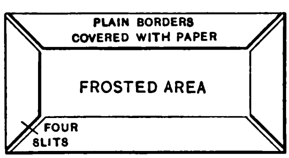
Handling Varnish by Air Pressure.—The paint stockroom of the Chicago Railways Company makes use of the shop air supply for a number of operations. Among these is the transferring of oil, turpentine and varnish from the barrels in which they are received into large elevated storage tanks. A barrelful of turpentine or varnish is rolled in front of one of the storage tanks and the plug is knocked out of the bunghole. Then a special emptying siphon is inserted. This device consists of a cone-shaped collar threaded to fit tightly into the bunghole. Inside of the brass collar is a piece of 1-in. wrought-iron pipe of such length that one end will reach to the bottom of the barrel and the other extend into the top of the high storage tank. The brass collar around this pipe includes a gasket so that when tightened in place the barrel is easily put under pressure by attaching a hose to a connection in the side of the brass collar. The shop air pressure is reduced to 10 lb. for this use. With this device the following time is required to transfer a barrel of new material into one of the elevated storage tanks: Turpentine, three minutes; oil, seven minutes; varnish, eight or nine minutes.

Sand-blasting of Cars.—The following method was devised at the Jersey City (N. J.) shops of the Hudson & Manhattan Railroad for the rapid sand-blasting of cars. In fact, this work is done at the rate of 1 sq. ft. per minute. The equipment includes an old car reservoir, which is filled with sand and supplied with air at 85 lb. pressure. Two inlets are used, one to force the sand down and the other to force it out of the tank at the bottom. The average life of a continuously used steel nozzle is about one day. With this equipment two men can sand-blast a 48-ft. car in eight to nine hours. The men who do this work under the present system receive respectively $2 and $1.75 a day each. The blasting is carried on outside the shop on the car-washing track, which is set in cement to permit easy cleaning.

Sand-blasting at Syracuse.—The sand-blast room at the Syracuse shops of the New York State Railways is used for sanding glass and for cleaning the metal parts of cars, either loose or on cars brought part way into the room. The simpler method as applied to smaller jobs calls for the use of a pail of sand and an air-line connection. The pail is suspended by a rope from the roof trusses. The sand flows through a hole in the bottom of the pail to the sand-blast pipe, where its momentum is accelerated by an 80-lb. air-line connection. The operator has nothing more to do than to steady the pipe and manipulate the valve that controls the flow of compressed air. A portable tank is also used for sand-blasting. The first was operated on the injector principle alone. It was found necessary, however, to add an air line at the top of the tank in order to force the sand down toward the injector. There are three valves on this tank; the top valve controls the air which enters the top; the second valve controls the injector action; the bottom valve regulates the flow of sand.

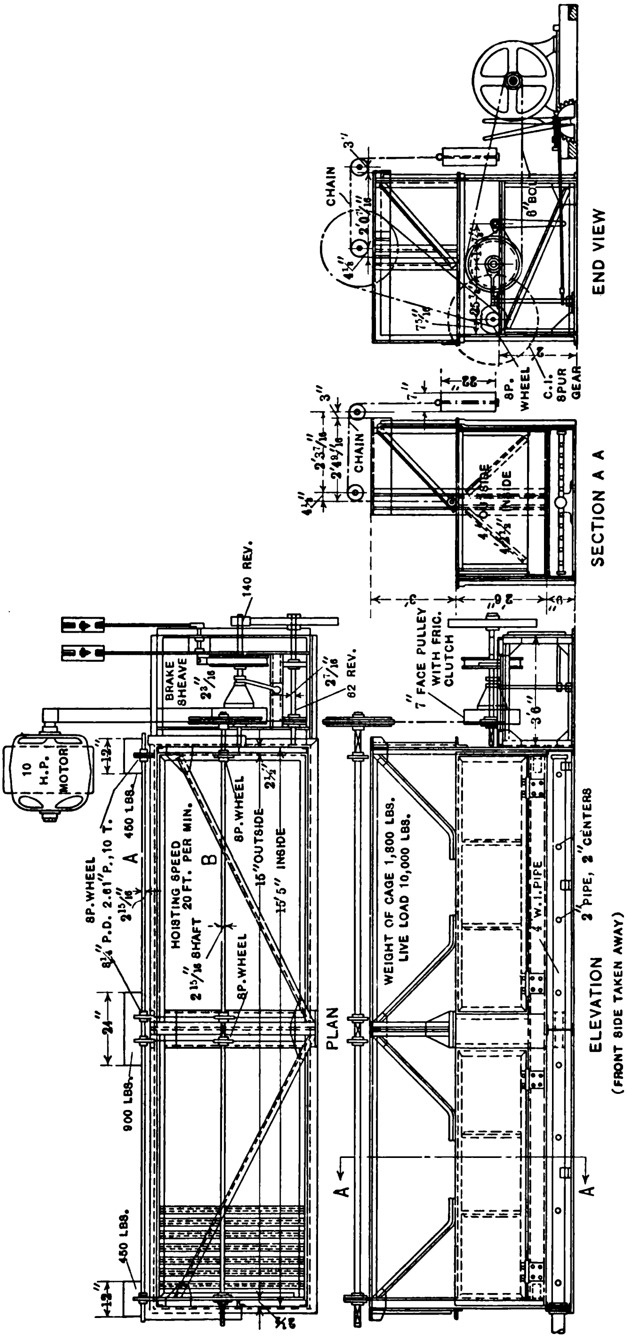
Cheap Transfer Type Signs on Glass.—Instead of painting or frosting signs or rules on glass, the Montreal Street Railway uses a process similar to that of the colored transfer pictures so popular with children. These signs cost only 3 cents to 5 cents each and remain on the glass despite any number of washings. The materials are furnished by a French firm.

Frosting Glass at Syracuse.—At the Syracuse shops of the New York State Railways, glass is frosted in the following manner: First, the glass is sand-blasted to get a ground surface and then the grounded side is covered with a solution of glue and soda. The soda is added in very small quantities to shorten the glue, namely, to take out its elasticity. After the glue has set so hard that it cannot be punctured by finger nails the glass is set to dry in the drying oven. The glue will begin to flake off immediately, taking particles of glass along. The resultant pattern depends upon the coarseness of the sand and the thickness of the glue. The oven mentioned is of galvanized iron and for gas operation, the burner being set at the bottom under an asbestos shelf. When glass is to be frosted a door at the top of the oven is opened to keep the temperature below 110 deg. Fahr. The glass is carried on cross-pieces which are adjustable for any pane within the limits of the oven. On these cross-pieces, the panes are placed vertically between barriers made of reversed nails.



Frosting glass, Syracuse.

The following method is applied to make a frosted glass panel with a plain border and a bevel corner effect: With ordinary stationer's mucilage a piece of paper is pasted over the portion of glass to be left plain, as indicated in the accompanying drawing, but a diagonal slit is left between the corresponding corners of the plain and frosted areas in order to obtain the desired bevel effect. Then all of the exposed glass is sand-blasted and the glue and soda solution is applied over the same. Upon this, the



Plan, elevations and section of gear-washing machine, Chicago railways.

glass is placed in the oven and the job is completed by immersion in a vat of water to soak off the paper.

Gear-washing Machine.—A machine for washing grease and dirt from motor and truck parts was built at the shops of the Chicago Railways in 1911. This machine is located in a covered aisle between the truck shop and the machine shop. Briefly, it consists of a large tank into which may be lowered a steel cage carrying the parts to be cleaned. The large drawing on page 60 shows its construction. This tank has brought about a substantial economy in cleaning gears, axle collars, armature heads, gear cases, journal boxes and other parts of trucks and motors. The dirty pieces are placed in the cage of the washing machine and lowered into a tank of hot water into which one-half barrel of soda is dumped twice each week. The water in the tank is kept hot by means of live steam furnished by a 4-in. main, terminating in a header with 2-in. branches placed in the bottom of the tank. Steam is charged into the cleaning mixture through rows of 1/8-in. holes in the tops of the steam branches. The cage of the cleaning machine holds five tons and is discharged once each hour. As the dirty castings are removed from the hot soda mixture they are swabbed with a broom.

The steel tank which holds the cleaning mixture has inside dimensions of 15 ft.×4 ft. 2 1/2 in. It is 3 ft. 3 in. deep and is made from 3/8-in. plates riveted to channel irons and angles. The cage in which the parts to be cleaned are placed for lowering into the tank also is built of structural steel. It weighs 1800 lb. and is designed to carry a load of 10,000 lb. This cage is raised and lowered by means of a 10-h.p. motor and a link belt transmission which includes a band brake to control the lowering, which is done by gravity. The cage has a lifting speed of 20 ft. per minute.

This washing machine and its operating mechanism are installed on a large concrete foundation so arranged that the washing tank extends but 16 in. above the floor. A concrete pit in front of the tank covered with iron grating receives the dripping from the castings as they are removed from the tank. This pit, which is 3 1/2 ft. wide and 4 ft. deep, also makes the lower part of the washing tank easily accessible. Sheet-iron covers for the top of the tank are provided to close it tightly when castings are being cleaned. A sheet-steel hood and stack have been placed above the tank to carry away the fumes.

VI

SANDERS AND SANDING DEVICES, SCRAPERS, BROOMS

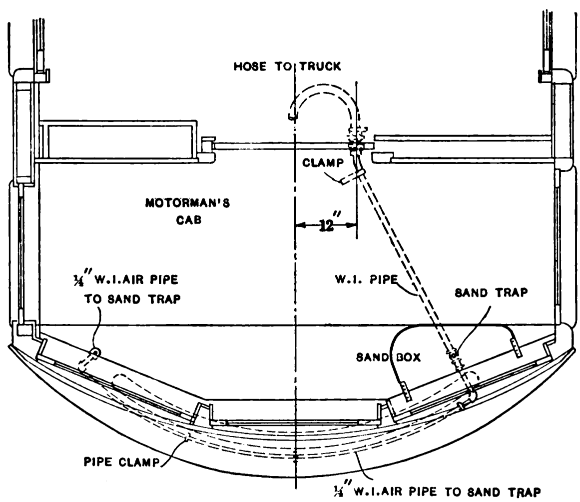
A Removable Sand Hopper.—As a substitute for a sand hopper under the car seats, the Fishkill (N. Y.) Electric Railway uses a substantial flat-bottom galvanized iron fire pail. In the bottom near the periphery is cut a 2-in. round hole which registers with a cast-iron mouth-piece fastened on the bottom with stone bolts. This mouth-piece fits into the pipe leading down through the car floor to the sand valve and track spout. A wooden plug fastened to the pail with a chain is used to close this hole in the bottom and it is withdrawn when the pail is in place over the sand valve. A number of pails filled with sand are kept on hand around the sand-drying stone and when a pail on a car is emptied it is lifted off and replaced by a full pail. The object in attaching the spout eccentrically is to permit the spout to be inserted in the sand valve pipe and then to turn the pail around under the seat where it is out of the way. The steep grades on the lines of the Fishkill Electric Railway make it necessary to use sand on both rails and no failures of this simple device have been recorded.

Air Sander on Interurban Cars.—A. C. Adams, superintendent motive power Oregon Electric Railway & United Railways, has designed and had in operation since 1912 on all of their passenger motor cars the simple and efficient air sand rigging which is shown in the accompanying illustrations on pages 62 and 63.

A large sand box made of No. 14 iron and having a sloping bottom is provided in the cab or vestibule of the car. The sand drops by gravity from the sand box through a 1 1/4-in. iron pipe into a trap made of a 1 1/4-in. × 1-in. standard pipe cross which is closed on the bottom with a 1 1/4-in. pipe plug. Should the trap become clogged the plug can be easily removed. Air is admitted to the trap from the whistle pipe through a 1/4-in. pipe into a horizontal nozzle which extends about three-fourths of the way through the trap and at right angles to the drop of the sand. The admission of air is controlled by a globe valve close to the motorman's brake valve. From the trap the sand is blown through a 1-in. pipe which connects to a 1 1/8-in. air hose 36 in. long, providing for the swing of the truck. The bottom end of the hose has a nipple which connects through a street ell into a 1-in. × 1-in. pipe cross, where the sand is separated by means of a wedge-shaped plug in the bottom of the cross. The separated sand goes to each leading wheel through 1-in. pipes which are bent to deliver sand to the rails directly ahead of the wheels. The pipes to the wheels are securely fastened to the truck frame.

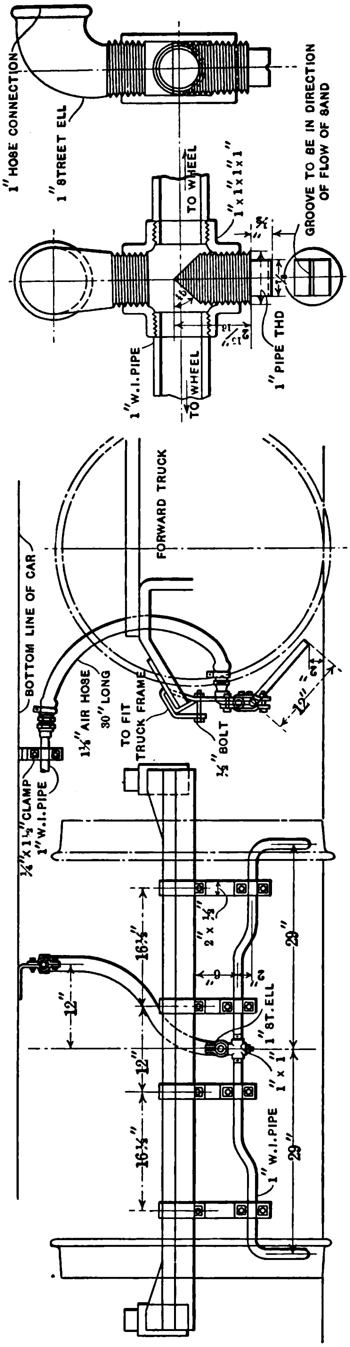
The rigging is made up in the company's shops, as all the material which enters into the construction is easily available in any shop of moderate size and it can easily be put together by ordinary mechanics.

In the entire time that it has been in operation not a single case has occurred where sand did not flow freely to rails. An over supply of sand cannot feed into the trap, nor has any trouble been experienced from sand blowing back into the sand box. Good sharp, clean sand is used, and any moisture therein is thoroughly removed by means of a sand dryer at the Portland shops.

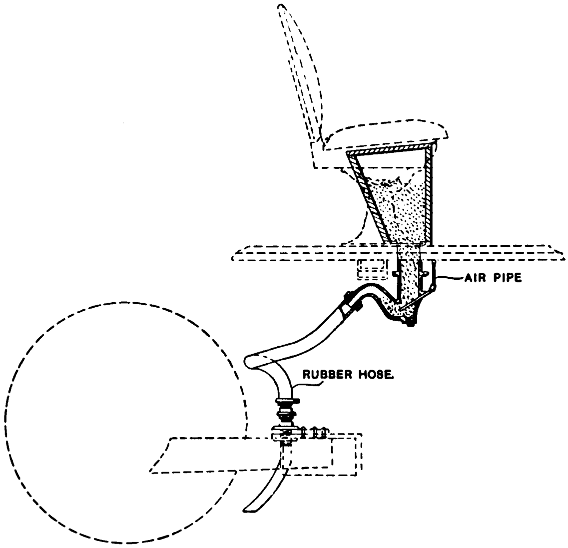


Air-sanding equipment, Oregon electric railway.

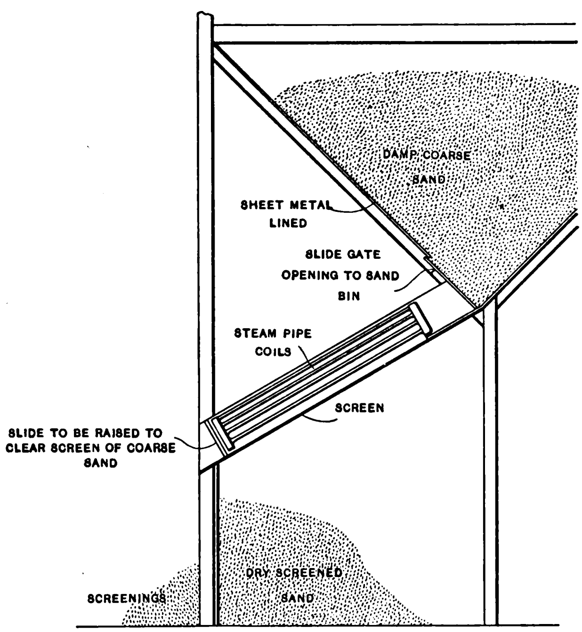
Simple Sanding Device at Rochester.—The Rochester (N. Y.) lines of the New York State Railways have equipped a number of their new cars with the simple sanding device shown in the upper view on page 64. Sand boxes are provided under four of the cross seats of each car and an outlet is provided in front of each driving wheel, the car being designed for single-end operation. Each sand box is equipped with an air-tight cover so that sand will not be blown into the car even if the sand pipe should become stopped up. Malleable-iron castings are bolted to the boxes below the floor, their form being like that of a sewer-pipe trap, and air is discharged into the sand at the bend of the trap. The sand pipe is carried on the truck frame, and it is connected to the trap by a length of hose. It thus assures the delivery of sand on the rail at the point



Sanding equipment and detail of pipe cross with wedge-shaped plug, Oregon electric railway.



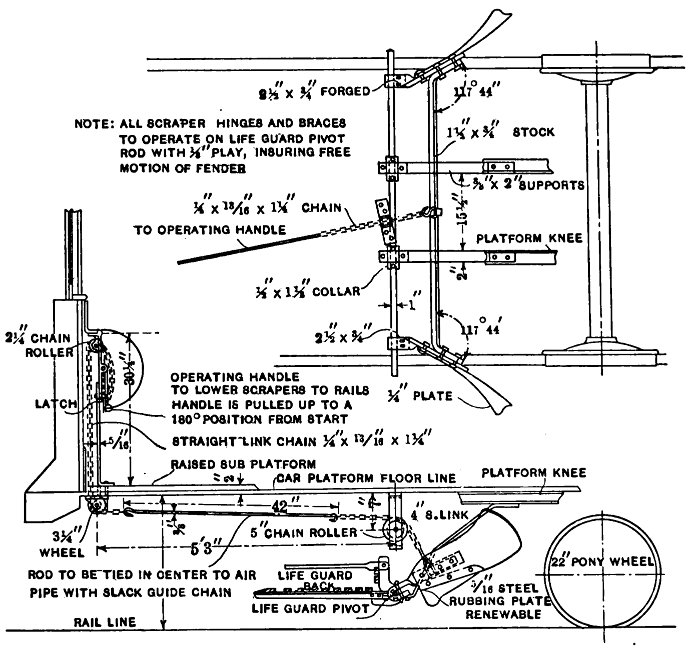
Sanding device, Rochester.



Section of sand-drying plant, Lincoln.

of contact of the wheel regardless of the alignment of the body with the trucks. The design is due to G. M. Cameron, master mechanic at Rochester.

A Novel Sand-drying Plant.—The operating department of the Lincoln (Neb.) Traction Company has built a novel sand-drying plant which is applicable to large or small railways. A wooden bin has been constructed in one of the carhouses to hold one car of sand. The sand is thrown into this bin by hand from cars alongside. The sides are sloped at an angle of 45 deg. to hoppers at one side of the bottom. These hoppers, when opened, allow the sand to flow onto the dryer beds, which slope at 30 deg. from the horizontal. Each dryer bed is a 6-ft. square

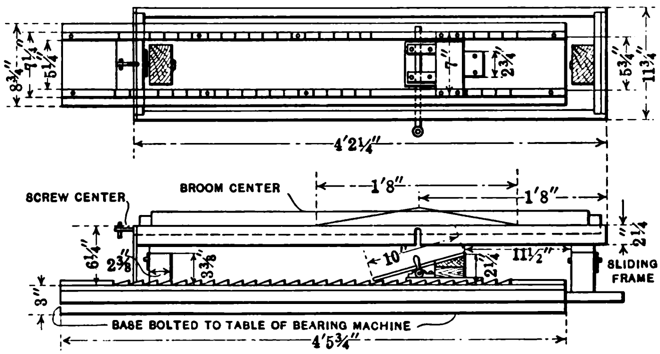


Snow scraper for limited clearance, Buffalo.

screen with 12-in. side boards. Nine four-pipe coils with branch tees are set on the dryer bed. These coils are arranged in parallel rows so that the sand may flow or be raked between them as it comes from the storage bin overhead. When the steam is turned on, the drying sand falls to dry-sand bins underneath the screen, and the coarse material rolls to the foot of the sloped dryer bed, where it is deposited in another bin after all the fine sand has passed through the screen.

Another novel feature in connection with the car sand-drying plant is the method of distributing it for use on the cars. A supply of car sand is available at several points on the property, and in order to reduce the cost of handling to a minimum it is shoveled into old cement sacks at the dryer and delivered to the supply points. After the sacks have been emptied directly into the sand boxes on the cars they are returned to the dryer for refilling. The outfit is shown on page 64.

Snow Scraper for Limited Clearance Space.—The International Railway Company, Buffalo, N. Y., purchased in 1913 nearly 300 near-side cars, which were fitted with scrapers designed in the mechanical department of the company. The clearance between the pony wheels of the forward truck and the backs of the life guards was too small in these cars to accommodate the usual design of scraper. The one shown in the illustration on page 65 was, therefore, manufactured in the company's shops, placed on all of the near-side cars and is giving excellent satisfaction. It will be noted that the foundation of the rigging is a 1 1/2-in.×3/4-in. steel cross-bar with bent ends. To this are bolted the hinges, which are forged from 2 1/2-in.×3/4-in. steel, and the renewable 5/16-in. steel rubbing plates. The hinges hook over the life-guard pivot rod and are held in place by cotter pins. The rubbing plates are raised and lowered by means of a chain attached to the middle of the cross-bar. After passing over idler pulleys, the chain terminates in an operating handle conveniently located back of the front dash.



Jig for boring holes in center boards for rattan sweeper brooms, Syracuse.

Jig for Boring Sweeper Broom Centers.—A simple jig for use in boring holes in broom centers for rattan broom snow sweepers has been used effectively in the Wolf Street shops of the New York State Railways at Syracuse. It is made up with a base fastened on the table of the boring machine and a sliding carriage in which the broom center is clamped. The base consists of a 1-in. board on the sides of which two 1-in. strips 1 3/8 in. wide are screwed, leaving a guide-way for the 1-in. carriage base. On top of the side strips and projecting over the carriage base are two saw-tooth racks.

A frame is mounted above the carriage base on heavy wood blocks.

Iron plates project downward from the ends of the frame and rock on bolts which extend through the blocks. The frame is shown in plan with the broom center removed in the upper view of the illustration. The lower view shows the broom center in position in the frame. The broom center is carried on screw center points which, when set up against the ends of the broom center, clamp it in the frame and the frame in one position at the same time.

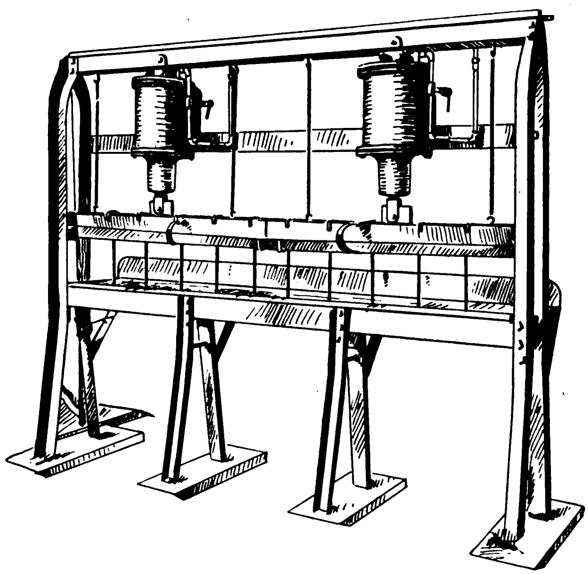
On the sliding base is a ratchet block carrying two ratchet springs, one on each side, their ends bearing on the saw-tooth racks. The teeth of these racks are spaced apart a distance equal to that desired between holes in each row in the board. The springs may be raised by means of a cam operated by a rod and handle. One side of the frame is notched out to clear this cam rod.

The operation of the jig consists in clamping the broom center in the frame. The carriage is then pushed to the extreme position at the right and the springs are released. The carriage is then pulled back to the left notch by notch. After a row of holes has been bored the broom center is rotated through an angle corresponding to the desired distance between rows and the operation is repeated. The jig has reduced what was formerly a very tedious operation to a very simple one.

Rattan Broom-filling Machine at Milwaukee.—In order to replace rotary brooms quickly and economically in the sweepers used by The Milwaukee Electric Railway & Light Company, Milwaukee, Wis., the mechanical department of this road has designed and built an efficient rattan broom-filling machine. The machine consists essentially of a structural-steel frame 12 ft. long, a length sufficient to permit filling an 8-ft. sweeper segment at one time, and 10 ft. in height, which places the work at a convenient elevation. Two standard 10-in.×12-in. brake cylinders, which are mounted on the upper portion of the frame and to which two bars are attached, furnish the pressure necessary to force the outer core and rattan into position in the U-shaped inner core. These when bolted together form a sweeper segment.

Just below the pressure bars is a table provided with a limit gage on one side and a slot formed with a Z-bar and angle on the other side. This slot receives the outer core, which is a U-shaped sheet-steel form with holes for bolts at uniform intervals. Hook bolts hung on the pressure bar guide the inner wooden core into position so that bolts may be inserted both through the outer and the inner cores when they, with the rattan, have been forced into permanent position. Four small spiral springs attached to the frame and pressure bars return them to the upper position when the air is released from the cylinder. Air for the pressure cylinders is supplied from the shop compressed-air system at 90 lb. per square inch. A view of the machine is shown in the illustration.

The process of filling a rotary broom segment, of which eight are required on each broom, consists in first placing the outer U-shaped core in the slot and then placing strips of thoroughly steamed rattan on the table as closely together as they can be conveniently laid with one end against the limit gage. After a sufficient number of rattan strips have been placed for a 4-ft. or an 8-ft. segment and the inner wood core has been clamped temporarily in position so that the hook bolts may be passed through the holes in both outer and inner cores, the temporary



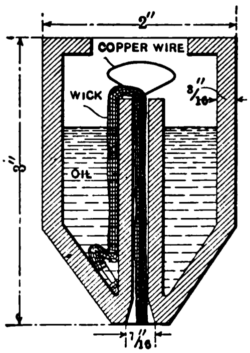
Rattan broom-filling machine, Milwaukee.

clamps are removed and the inner core is lowered to the rattan. The air valves are then opened at one or both cylinders as required, which lowers the pressure bar until the outer and inner cores with the rattan between them are forced into position. Bolts are then passed through both and pulled up tight, and next the air is released from the cylinders, allowing the pressure bar to return to the normal position. The removal of the hook bolts then permits the finished broom segment to be removed. The whole process requires about twenty minutes, but when it was done by hand the same work used to require about two hours.

VII

LUBRICATION

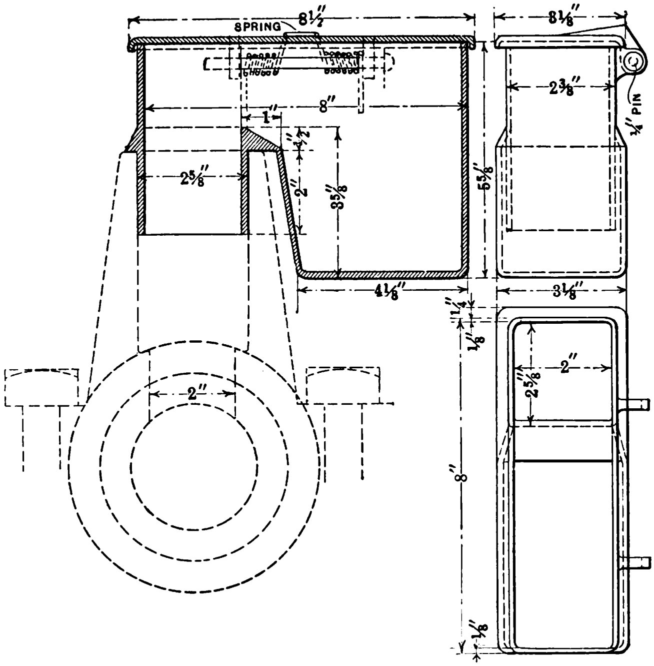
Capillary Oiler.—When the oiled waste in the armature-shaft oil cups is replaced by the Cincinnati capillary oiler illustrated the quantity of oil required is materially reduced and heated bearings are practically unknown. The capillary oiler consists of a gray cast-iron shell the details of which are shown. Plain motor oil is supplied to the reservoir, and the wick is manufactured from the best quality of worsted yarn. The reservoir end of the wick is held in the oil by a lead weight, and the other end is forced through the oil-feed duct to the bearing area by a short piece of twisted copper wire. The copper wire also acts as a conductor of heat from the bearing to the oil, thus eliminating the oil coagulation which might be expected in the duct.



Capillary oiler, Cincinnati.

Oxy-acetylene Process for Changing Grease to Oil Lubrication.—A perplexing problem for the users of the old grease-cup motors is to adapt them for proper oil lubrication. The Hartford shops of the Connecticut Company have accomplished this desirable change on GE-800 motors by using the oxy-acetylene welding process for closing the bottom of the large grease openings in the armature and axle bearings. After the welding was completed a hole was drilled in the bottom for the insertion of a wick which is soaked with oil. This method gives far better lubrication than was formerly obtained by using grease and felt.

Oil Box for Grease-type Motors.—The Virginia Railway & Power Company, Richmond, Va., still operates some GE-57 and GE-67 motors, which were designed originally for grease lubrication. It has been found possible, however, to use oil and wool waste packing with much greater satisfaction and economy by installing oil boxes of the design shown in the accompanying drawing. The box is riveted to the motor frame and has a spring cover which effectively excludes dust. Oil cups of this type have been applied to the armature bearings of all motors of the above types, resulting in substantial increase in the life of the bearings and fewer hot and melted bearings, due to the better lubrication obtained.



Oil box for grease-type motor, Richmond.

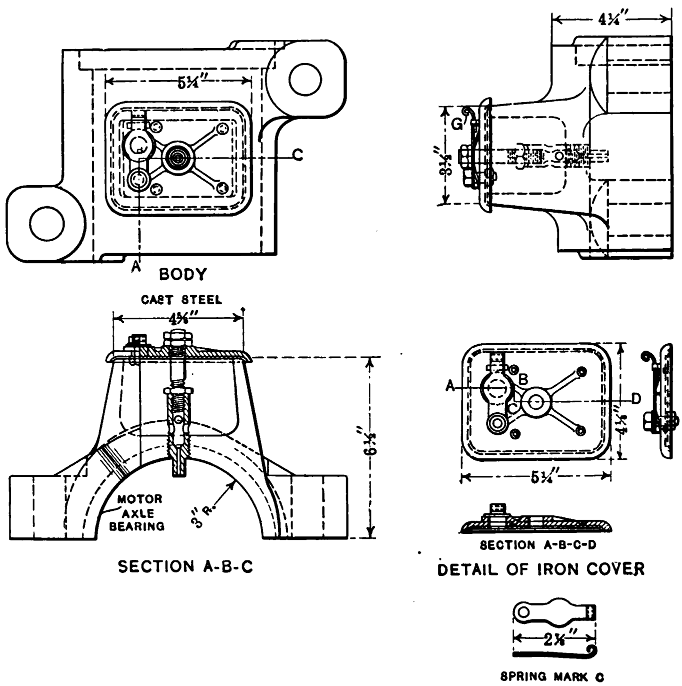


FIG. 1.—Oil cup for axle cap, commutator end, West. 81 motor, Brooklyn.

Before putting these oil boxes on the GE-57 motors the company experienced a great deal of trouble with bearings on account of water getting into the armature boxes, and it was necessary to drain the oil wells after any considerable spell of wet weather. The application of these oil cups has entirely done away with this trouble.

Integral Oil Cups in Brooklyn.—The Brooklyn Rapid Transit Company still uses a large number of motors which originally were made for grease lubrication. The attempt to use oil cups in these motors has not been entirely successful, as the grease cavities in the frames were too

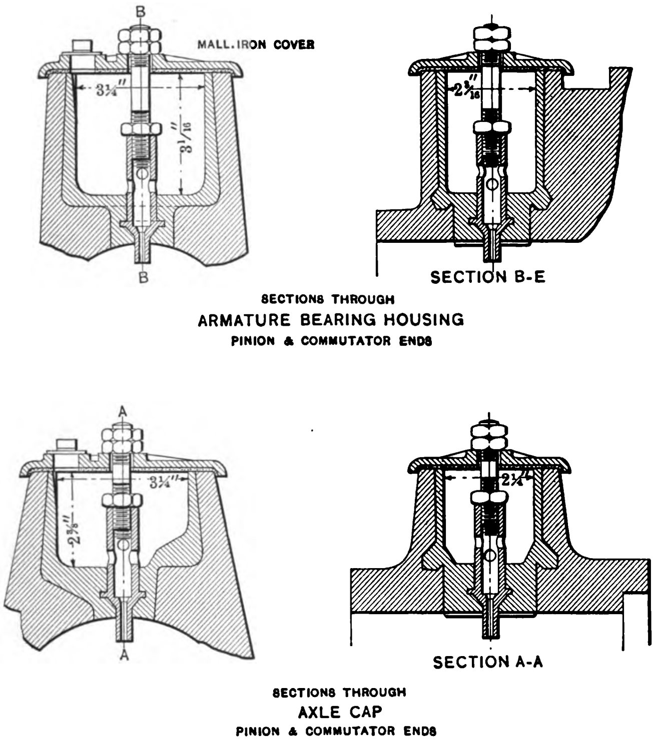


FIG. 2.—Babbitted oil cups for No. 81 motor, Brooklyn.

irregular to allow a tight fit. Hence many cups were lost by being thrown out of the frame when the trucks passed over special work or rough spots in the line. Another difficulty with the cups was the fact that they had a needle valve to control the feed. Frequently these valves would stick and thereby cause the loss of armatures. To overcome these troubles the mechanical department of this company has adopted an oil receptacle which is a part of the motor frame. It is made in two forms as shown in the drawings. Fig. 1 on page 70 shows the construction when the oiling method is embodied in a new axle cap casting, while Fig. 2 shows how armature bearing and axle castings can be turned into oiling cups by babbitting. In both patterns the oil is fed through a wick-filled spindle. Fig. 3 shows a later oil-post improvement as applied to the West. 81 motor. The post is now built in two parts to permit the wicking to be inserted before installation in the oil cup. Ninety-two strands 4 in. long are placed in each hole for the armature bearings and 112 strands 4 in. long are placed in each hole for the axle bearings. The brass casting into which the feeder post is screwed is babbitted into the bottom of the cup. The dimensions shown are not

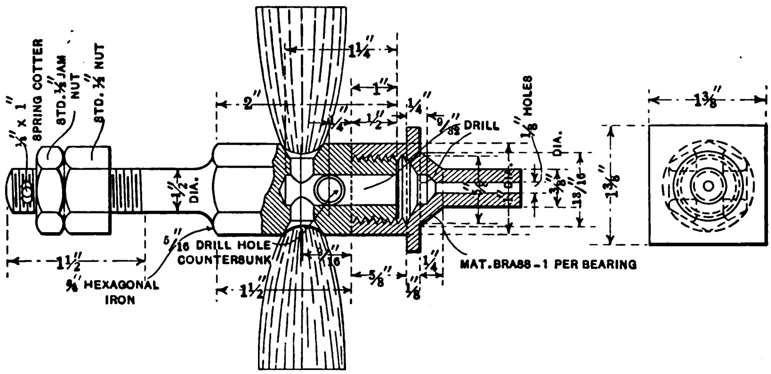


Fig. 3.—Revised oil feed attachment for motor bearings with babbitted oil cups, Brooklyn.

always the same, as this construction is also used on Westinghouse 68 and 81 and on GE-57 motors. The covers of all oil boxes are similar, being made of malleable iron with a leather gasket to insure the exclusion of dust when the jam nut is tightened. The receptacles are filled with oil after raising a 1-in. flat spring in the cover. These oil boxes replace the independent oil cups used on the GE-57, GE-64, Westinghouse 68 and Westinghouse 81 motors operated under the surface passenger cars.

Lubrication in Brooklyn.—The following lubrication instructions are in vogue on the Brooklyn Rapid Transit System to supplement an oil standardization chart.

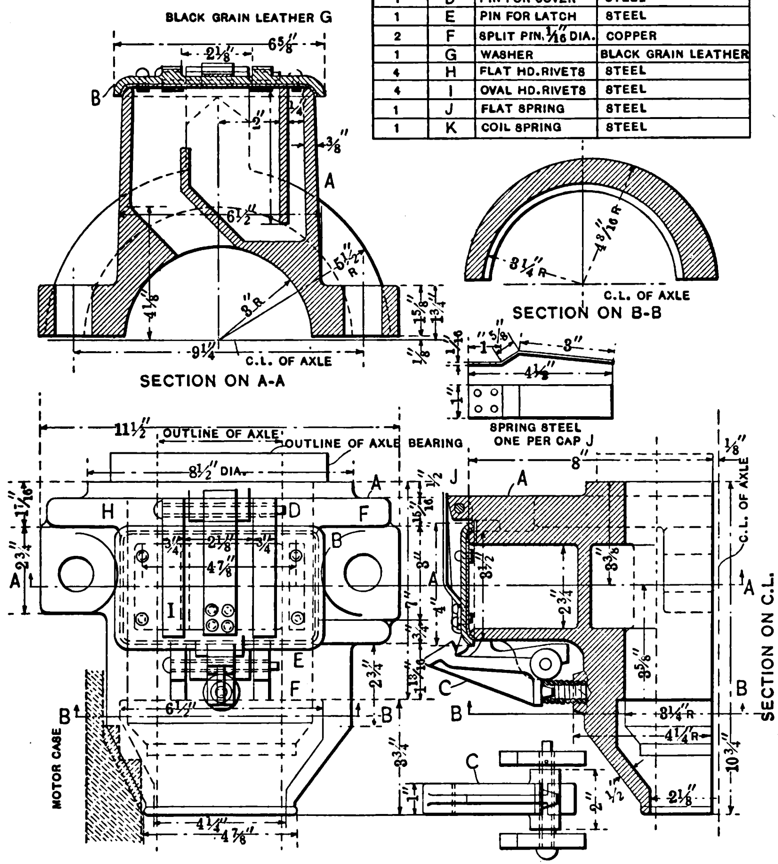
"In lubricating Westinghouse No. 68 and No. 81, or other motors equipped with babbitted oil cups, enough oil is to be added to fill cups to within 1/2 in. of the top. In removable type cups on General Electric No. 57 or other type motors, add enough oil to make cup half full.

"All shops will burn their oily waste in heating plant boilers during winter months when boilers are in operation. At all other times they will send the waste away in cans on the rubbish-collection car, to be burned at the incinerator plant. Under no circumstances is waste to be burned in the blacksmith forges or inside of the shop buildings of any shop."

Improvements in the Lubrication of Elevated Motors.—The motor equipment of the elevated divisions of the Brooklyn Rapid Transit System is made up chiefly of eighty Westinghouse 50-B, 170 type 50-E,

BILL OF MATERIAL

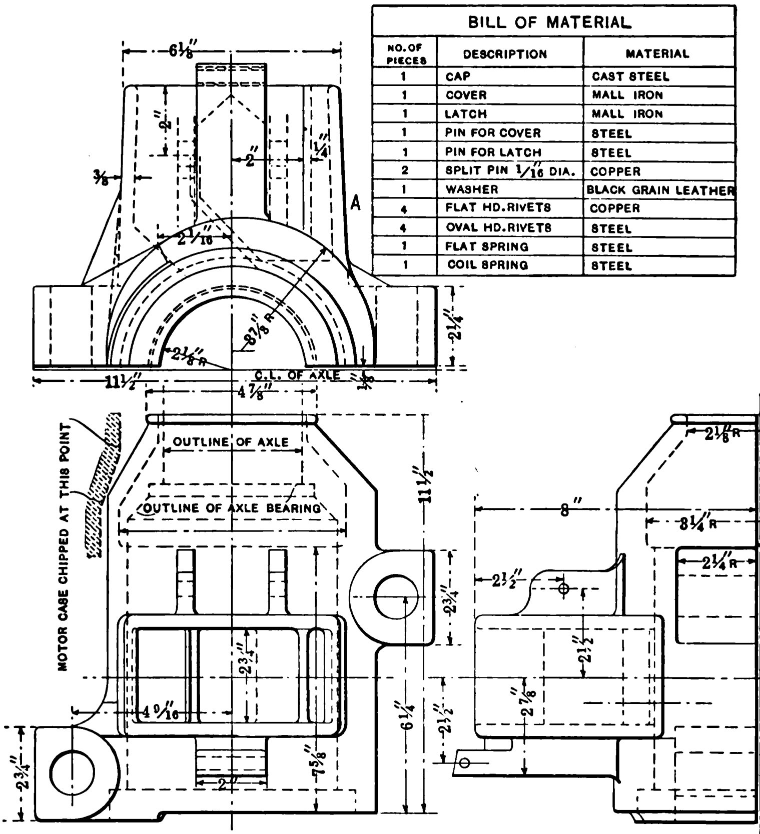
NO. OF PIECES	MARK	DESCRIPTION	MATERIAL
1	A	CAP	CAST STEEL
1	B	COVER	MALL IRON
1	C	LATCH	MALL IRON
1	D	PIN FOR COVER	STEEL
1	E	PIN FOR LATCH	STEEL
2	F	SPLIT PIN, 1/16" DIA.	COPPER
1	G	WASHER	BLACK GRAIN LEATHER
4	H	FLAT HD. RIVETS	STEEL
4	I	OVAL HD. RIVETS	STEEL
1	J	FLAT SPRING	STEEL
1	K	COIL SPRING	STEEL



No. 81 motor axle cap, capillary type, pinion end, Brooklyn.

876 type 50-L and 202 type 300. The first three types are 106 h.p. each and the last of 200-h.p. capacity. It will be seen from the foregoing that the 50-L motor comprises about two-thirds of the active passenger equipment. For this reason, the improved lubrication of this motor as hereinafter described has been one of the most important influences in the

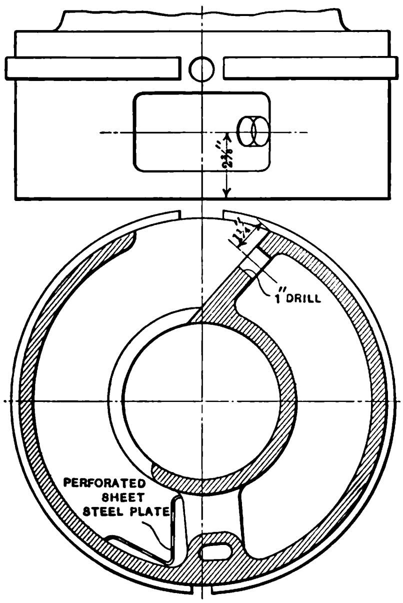
reduction of the cost of lubrication on the elevated lines from 27 cents in November, 1907, to 11 cents per 1000 car miles in June, 1912. The 50-B and 50-E motors, which are substantially alike, have also had their oiling system improved. The No. 300 commutating pole motor, however, has remained unaltered because it has given satisfactory service and low lubricating costs ever since its installation.



BILL OF MATERIAL		
NO. OF PIECES	DESCRIPTION	MATERIAL
1	CAP	CAST STEEL
1	COVER	MALL IRON
1	LATCH	MALL IRON
1	PIN FOR COVER	STEEL
1	PIN FOR LATCH	STEEL
2	SPLIT PIN $1/16''$ DIA.	COPPER
1	WASHER	BLACK GRAIN LEATHER
4	FLAT HD. RIVETS	COPPER
4	OVAL HD. RIVETS	STEEL
1	FLAT SPRING	STEEL
1	COIL SPRING	STEEL

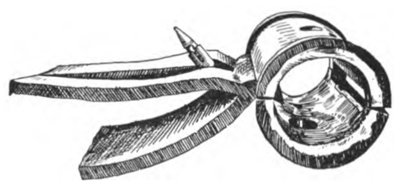
No. 81 motor axle cap, capillary type, commutator end, Brooklyn.

In September, 1910, after a study extending over two years, the mechanical department undertook a complete change in the lubrication of the No. 50-L motor. This design had given much trouble from hot armature bearings owing to lack of oil at the pinion end bearing, a condition which was due to the extreme length of 3 in. from the opening for the waste in the bearing to the pinion end of the bearing. Different types of oil-ways had been previously tried but without success. The first change was to drill a 1-in. hole in the under side of the bearing with its center 1 in. from the end of the bearing. Then, as shown in one of the accompanying views, a piece of 1-in.×4-in. round felt was placed in this hole, and the bottom of the felt was immersed in the drip oil which collects in a receptacle in the bottom of the housing. By capillary attraction, this felt feeds the oil over again to the end of the bearing, thus keeping it properly lubricated. The pinion end bearing was also shortened 1/4 in. and a felt washer 1/4 in. thick ×1 1/2 in. wide was installed between the bearing and the inside end of the housing to prevent gear grease from getting into the bearing and clogging the oil passage. This change as shown in the same illustrations has practically eliminated trouble from hot bearings. A third change was in the location of the drip hole. The old drip hole in the back end of the housing was about 1 1/4 in. from the bottom. This hole was plugged and replaced by another of the same size but drilled 1 in. higher to allow a greater depth of oil in the waste oil receptacle.

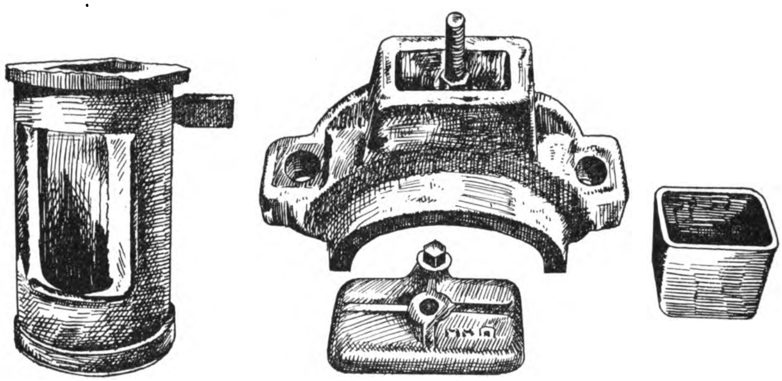


Oil hole drilled in housing of West. 50-L motor, Brooklyn.

In the original design of the No. 50-L motor, no means had been provided for measuring the amount of oil in the lower part of the housing. Consequently, all the oiler could do was to pour the lubricant on top of the waste. As the motor was usually warm at the time, the oil would pass through the waste to the armature shaft and out between the shaft and the bearings to the gear case or to atmosphere. To eliminate this trouble, a 1-in. hole, as indicated in the accompanying drawing, was drilled in the blank side (or side opposite the waste) of the housing, thus affording a gage for measuring the depth of oil at times and a well for holding additional oil as needed. The oil runs down the blank side of the housing to a partition which contains a hole through which the waste can draw the oil.


Split-felt feed for West. 50-L motor, Brooklyn.

The changes in the 50-B and 50-E motors were not so radical as in the 50-L, but they were equally effective. Unlike the 50-L, these motors are felt-lubricated. In the original design, a single piece of felt, 1 in. thick×6 1/4 in. long×5 in. wide, extended from the oil well to the armature bearing. It was thought the oil would pass to the bearing by capillary attraction, but it was found the the oil supply was interrupted by the spring pressure of the nine-pronged fork which held the felt in place. The removal of some of the prongs would have done little good so long as the pressure of the fork was exerted against the oil-carrying felt. Relief was finally obtained in the following manner: The felt was cut in half in a horizontal plane and the upper half slit lengthwise up to within 2 in. of the armature bearing, except that the base of the slit was cut to make a hole of 2-in. diameter to permit the insertion

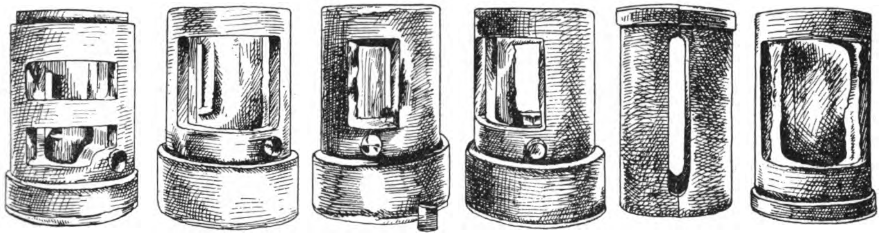


Felt feed and washer, West. 50-L motor; babbitted oil cups in axle cap casting cover for same and discarded independent cup of West. 81 motor, Brooklyn.

of the fork at the crotch made in the felt. As shown in the lower illustration on page 75, the felt is now kept in place by having the prongs bear against the lower half only, while the slitted upper pieces, which are overlapped on the fork, are free to carry the oil from the well to the bearing. The specially selected felt used for this purpose is furnished in strips 1 in. thick and 60 in. to 72 in. wide.

Changes in the Lubrication of Surface Motors.—During 1910 the Brooklyn Rapid Transit System began to install the integral or babbitted oil cup, previously described, to replace the independent oil cups of the GE-57, GE-64, Westinghouse 68 and Westinghouse 81 motors. The independent oil cups were not entirely satisfactory as many of them were shaken out of the grease cavities on account of vibration, etc., while the use of a needle valve to control the feed sometimes failed to give lubrication through the gumming of the oil. An accompanying illustration of the axle cap casting of the Westinghouse 81 motor shows the babbitted cavity, which was originally 1 1/2×2 in. in size, and also a specimen of the discarded oil cup. The enlarged hole for the babbitted cups is obtained by chipping out the motor shell with an air hammer.

A number of additional improvements were made in the No. 81 motors following its transfer from the elevated to the surface lines. As 1820 motors of this design are in use, it is the most widely employed type on the system. One change, as shown in an accompanying illustration of old and new designs, was to remove from the armature bearing a rib which had proved very troublesome because it pulled the felt feed away from the shaft. A second change was to chamfer the holes in the commutator and pinion end bearings at the top to aid the oil in going more directly to the bearing. The bottom holes at both the pinion and commutator ends were also enlarged so that the felt would not be caught.



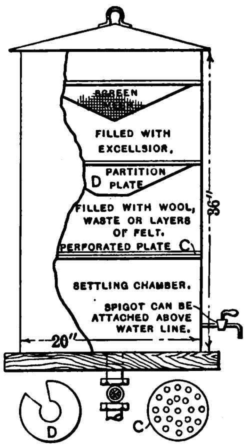
Old ribbed and new ribless armature bearing of West. 81 motor; chamfered holes of West. 81 motor, commutator and pinion end bearings; armature bearings of the West. 50-B (and 50-E) motor and of the West. 50-L motors, respectively, Brooklyn.

A further step in progress of increasing lubrication efficiency on motors originally designed for grease feed is shown in the axle cap drawings. These axle caps have been designed to be, as nearly as possible, the same in principle as oil well housings on modern type motors. The sections show the arrangement for measuring the amount of oil in the cups. These caps are installed as it becomes necessary to replace those of the original designs and they will eventually be placed on all Westinghouse No. 81 motors.

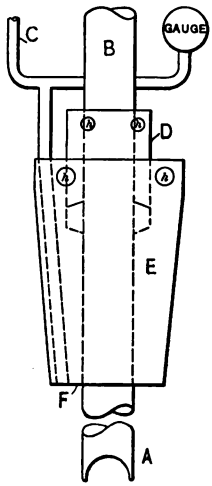
Keeping Oil Warm.—In the Denver & Interurban Railway, the carhouse adjoins the power station and an ingenious method is followed in keeping the lubricating oil warm in winter. The oil tank is surrounded by a box in which is a coil pipe supplied by steam from the power station so that the temperature of the oil when taken from the pump is about 90 deg. In consequence the company can use a heavy cylinder oil in its armature boxes.

Keeping Oil Warm at Hartford.—A feature of the lubrication practice at the Hartford shops of the Connecticut Company is that the day's supply of car oils is kept in the shops in a metal-lined box, which during cold weather is heated by a bank of incandescent lamps attached to the inner side of the cover.

Oil Economy at New Orleans.—At each of the carhouses of the New Orleans Railway & Light Company a journal box waste-soaking and draining tank has been installed in order to save lubricating oil. The tanks are made of galvanized sheet steel and are fitted with tight covers. Each tank is provided with a draining basket into which the supply of oil-soaked waste for immediate use is placed until the excess oil has been drained out. A supply of waste sufficient to last a week is stored in the bottom of the tank under the oil and allowed to remain there at least forty-eight hours.



Oil reclaiming tank, Washington, Baltimore and Annapolis railway.



Siphon head for oil barrels, Western Ohio railroad.

Oil Reclaiming Tank.—The accompanying drawing shows a compressor oil reclaiming tank which was built by the Washington, Baltimore & Annapolis Railway in line with suggestions made by the lubricating contractor. The railway has also devised two steam-heated soaking tanks for reclaiming waste and draining car oil.

A Siphon for Emptying Oil Barrels.—For use on the Western Ohio Railroad a novel device has been developed for the purpose of transferring oil and other liquids from barrels to storage tanks. In brief, the device consists of a siphon head which is screwed into the bunghole of an oil barrel and through which a piece of pipe is extended to the bottom of the barrel. A small hole in the siphon head is connected to a compressed-air supply, and the air pressure thus established in the barrel forces the oil out through the discharge pipe, transmitting it, in fact, to considerable distances if necessary.

The storage house of the company at Wapakoneta, in which the oils are kept, is somewhat isolated, and the compressed-air system used in the shop is not extended to it. In consequence, a portable tank has been arranged for supplying compressed air at the storehouse. This tank is an ordinary main reservoir, 16 in. in diameter by 48 in. long, such as is used on an interurban car. It is mounted on a two-wheel truck and after being charged with air in the shop is wheeled from there to the oil house. When charged at a pressure of 60 lb. per square inch it affords sufficient air to transfer the contents of a 50-gal. barrel to any desired receptacle.

The discharge pipe is made up of a piece of 1/2-in. standard gas pipe, which is turned in a lathe to give it a smooth surface capable of making a close fit in a stuffing box. The siphon head through which the discharge pipe is extended is made of cast iron. It is about 3 in. long, threaded on the outside with sixteen threads per inch and cut on a taper of 2 1/2 in. per foot, as this taper appears to be the general standard used for the sides of bungholes in oil barrels. A stuffing box is inserted in a threaded recess at one end of the siphon head to hold packing around the discharge pipe.

The siphon head is drilled with a 1/4-in. hole, and into this is inserted a 1/8-in. air-supply pipe on which are mounted a pressure gage and an air cock to release the pressure in case of accident to the barrel or to the discharge line.

In operation, the siphon head is screwed into the bunghole of the barrel until it is air-tight, and the 1/2-in. discharge pipe is shoved down through the siphon head until it reaches the bottom of the barrel. Air is then turned on to the air-supply pipe marked *C* on the accompanying illustration, the pressure being read on the gage. This air pressure is transmitted to the barrel through the hole in the siphon head marked *F* and the oil is forced up through the pipe, emerging at the point marked *B*, from which it is delivered into any desired receptacle.

The holes shown in the upper part of *E*, the siphon head, and *D*, the stuffing-box nut, are bored to provide a means for screwing the two castings into place, as a pin inserted into one of the holes takes the place of a wrench and aids in assembling the apparatus at points far away from the shop.

The object of the pressure gage is to enable the operator properly to adjust the air pressure and to prevent the barrel from being subjected to a pressure of more than 10 lb. or 12 lb. per square inch. This pressure has been found to be sufficient to transfer the most viscid oils to the storage tanks, which are set at an elevation of about 7 ft. above the top of the barrel.

The device has been found to be very satisfactory and decidedly convenient. It is easy to assemble, and about five minutes' work is sufficient to make complete preparations to transfer liquids, as it is necessary only to drive in the bung and screw the head into place in the bunghole. The bottom end of the discharge pipe is notched out as shown in the illustration, and this permits draining the barrel practically complete.

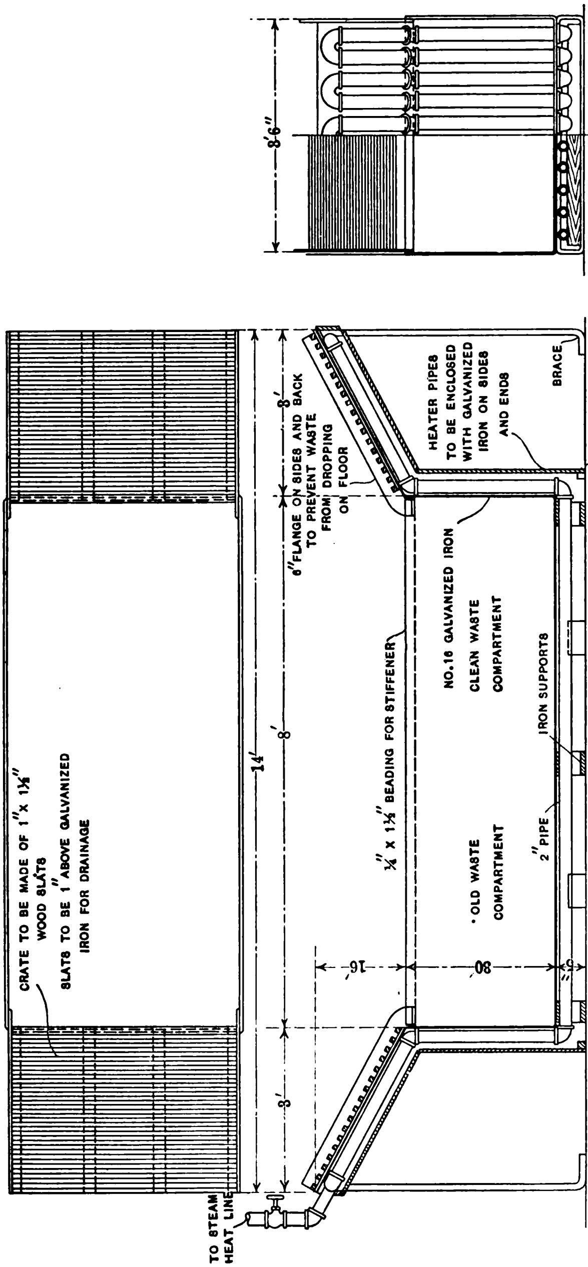
With the device it has been found that about ten or fifteen minutes is required to transfer 50 gal. of such oils as turpentine, signal oil, boiled linseed oil or compressor oil. Oils of greater viscosity than those, such as car oil or cylinder oil, require a proportionately longer time.

Waste Saturating and Renovating Plant at Chicago.—The mechanical department of the Chicago Railways Company changed its method of saturating waste in the year 1912. Originally this work was handled at the various carhouses, substations, and generating plants. This method was not considered economical, and the fact that a large number of proper installations at these points would be expensive led to a decision to prepare all waste at a central point. In addition to saturating new waste, the question of renovating and resaturating old waste was carefully considered. As a result of this investigation a plant was installed at the Chicago Railway shops on Fortieth Avenue between Lake Street and Washington Boulevard which not only prepares all the new waste used by this company but restores old waste to a usable condition.

The plant consists of a two-compartment tank, each tank being 34 in. wide, 30 in. deep and 12 ft. in length. One compartment is used for renovating old waste and the other for saturating new waste. The tank has been installed so that the uppermost portion of the drip rack is slightly above the workman's waist line when he stands on the footboard. As is shown in the illustrations, it is entirely surrounded with steam-pipe coils which keep the oil in a fluid condition at all times. This hot oil not only reduces the time required to saturate waste but results in better saturation.

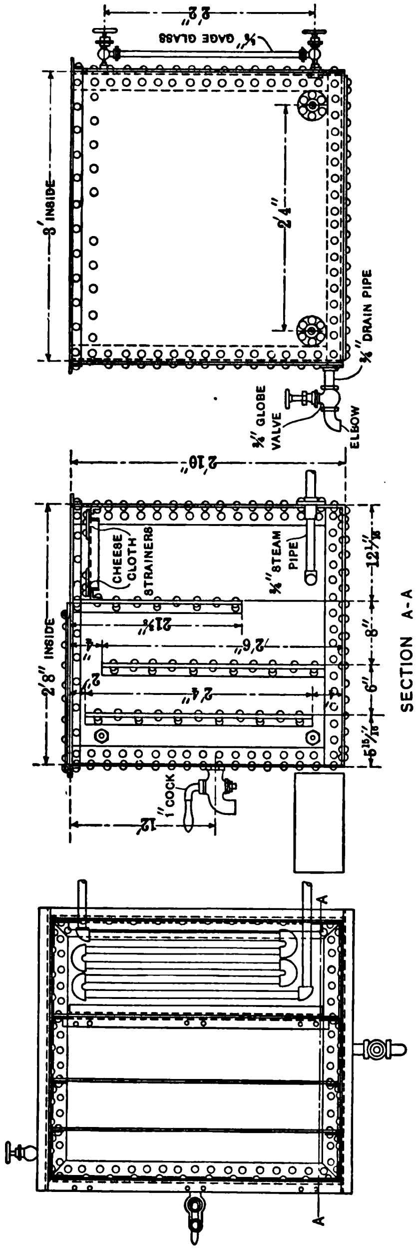
In preparing to renovate old waste three barrels of car oil are turned into one of the tanks. After this is properly heated 100 lb. of old waste is put into the oil and allowed to soak from fifteen to twenty minutes. At the end of this time the man in charge of the plant works the waste back and forth through the oil with a pitchfork. This operation continues about two or three minutes, and then the waste is thrown on the drip rack, where it is allowed to drain for twenty minutes. At the end of this time it is ready for use and is deposited in cans used for transporting it to various stations on the system.

When new waste is saturated five barrels of oil are turned into the other compartment and 400 lb. of new wool waste is thrown into the tank, where it is allowed to soak for half an hour. At the end of this period



Details of waste-saturating plant, Chicago railways.

the waste is thrown on the drip rack and allowed to drain for fifteen minutes, when it is ready for use. The size of the rack is such that 75 lb. of saturated waste can be placed on it to drain at one time. One man is able to prepare all the waste used by the Chicago Railways Company and prepares about 800 lb. of renovated waste and a similar amount of new waste in a nine-and-one-half-hour day.



Tank for reclaiming compressor oil, Brooklyn.

It is evident to those familiar with the old method of preparing waste that the time required is greatly reduced. Heretofore this company saturated all waste at the various stations in cold oil. The new waste was allowed to soak in the oil about forty-eight hours before it was placed in the drain tank, where it was allowed to remain twenty-four hours, thus making the total time three full days. Under the present method it will be noted that the time required to prepare either new or old waste is less than one hour. Not only is the time reduced but the cost of saturation is lowered about 500 per cent., and at the same time the waste is saturated better. Probably the largest item of economy gained from employing a plant of this character will be found in the renovation of old waste which originally was discarded. The saving not only includes the waste but a large proportion of oil. Under the new system the mechanical department estimates that it will be unnecessary to buy any new wool waste for several years. It also plans to reclaim the babbitt which is usually found in the caked portions of old waste. After a certain amount of old waste has been cleaned the oil is taken from the old-waste compartment and the sediment removed. This sediment is placed on a large piece of sheet steel and the oil burned out of it. The sheet-steel table is so arranged that as the oil burns the babbitt is melted and allowed to run into a mold at one end. Similar systems are employed by several of the large steam roads and the babbitt-saving feature is considered one of the most economical features of the plant.

With a plant like this great economies are possible. For instance, the oil required to saturate 1 lb. of new waste is 0.35 gal. and that required to saturate old waste is 0.035 gal. The labor cost of the new system is almost negligible, being 3 mills per pound of waste handled. The plant itself is comparatively inexpensive and expert labor is not required in its operation.

Safety Waste Cans at Chicago.—A special form of waste receptacle has been placed at those locations in the shops of the Chicago Railways where much wiping waste is used. The receptacles are large cylindrical waste cans into which a screen has been supported about 6 in. from the bottom. As the waste is thrown into the cans it rests on the screen and the oil and gasoline drain to the bottom space. Dirty waste collected from such cans can safely be thrown directly into the furnace with little danger of flashing back into the fireman's eyes.

Reclaiming Compressor Oil in Brooklyn.—The drawing on page 82 shows the details of a four-chamber metal tank used by the Brooklyn Rapid Transit System for the reclamation of compressor oil. The first section is provided with cheesecloth strainers. The oil is gradually cleansed as it percolates these strainers. On reaching the bottom of the first chamber it flows into the second compartment, then into the third compartment and finally enters the fourth compartment through an opening at the bottom. By the time the oil has reached the fourth chamber it is thoroughly satisfactory for re-use. One faucet is provided to draw clear oil and another is installed for relieving the tank of sediment and water. Steam coils are used to maintain the temperature of the oil at 100 deg. Fahr. A gage is also attached to the tank to show the relative amount of oil and water contained therein.

VIII

BEARING PRACTICE

Cast-iron Armature Bearings and Motor Axle Linings.—Cast-iron motor axle linings have been in use on Cincinnati car equipment for several years and are giving excellent results. No special lubricant has been employed and no babbitting is required.

In 1912 the company began to apply cast-iron sleeves to the bearing ends of the armature shafts as fast as they came into the shop for repairs, and the brass bearings are being replaced with cast-iron bearings, thus making a cast-iron-on-cast-iron bearing surface. The sleeve is shrunk on the armature shaft and eliminates the dust ring. No special lubricant is required, and the fact that no perceptible wear has been noted after eight months' service indicates that the life of the bearing will be much more than that received from ordinary brass bearings and that the quantity of oil required will be materially reduced. The fact that the cast-iron bearing does not require a babbitt lining, as well as the difference between the cost of brass and cast iron, materially reduces the cost of manufacture and maintenance.

Bearing Practice at New Orleans.—The bearings made in the foundry of the New Orleans Railway & Light Company are cast from a plastic bronze mixture consisting of 10 per cent. of lead, 1 per cent. of tin and 89 per cent. of copper. The journal brasses are finished on the axle sides by polishing with emery cloth fastened around a wood cylinder which revolves rapidly in a high-speed polishing lathe. This gives the bearings a smooth cylindrical-shaped inside surface. In the manufacture of bearings, trolley wheels and other small castings the foundry melts about 550 lb. of metal a month.

In babbitting the armature bearings for the GE-57 motors the bearing halves are centered with wedges about the armature shaft after a piece of paper has been wrapped around it. The oil hole is filled with a plug and the babbitt is poured in the end of the shell. By following this method of babbitting it is unnecessary to rebore the bearings; and an increased life is obtained from the bearings because the hard skin forming over the outside of the babbitt is not cut away before the bearing is put into service.

Bearing Practice at Columbus.—As on many other roads, the master mechanic, of the Columbus (Ohio) Railway & Light Company, Charles

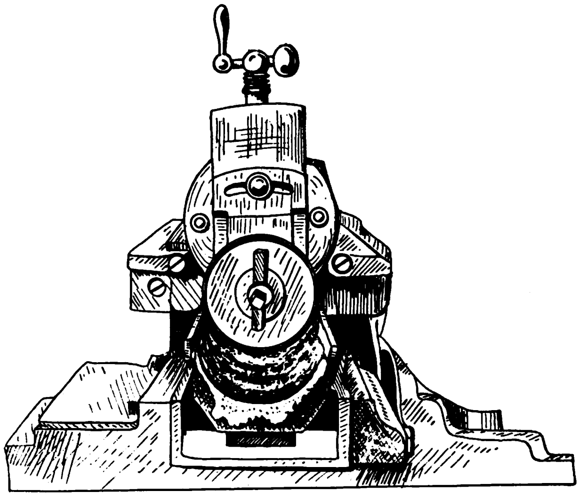
E. Hott, has devised a special bearing metal formula. He uses 77 per cent. copper, 8 per cent. tin and 15 per cent. lead. The copper is placed in a crucible and allowed to reach the melting temperature, then the tin and lead are added. After all the metals have been thoroughly mixed by stirring, the mixture is poured into small pigs and allowed to cool. This process has been found to give a tough material of uniform texture whose turnings when the castings are finished are blue and not copper-colored.

The same process is used in making the babbitt metal as in the bearing metal. A mixture of 16 2/3 lb. of tin, 8 1/3 lb. of antimony and 8 1/3 lb. of copper is melted and poured into pigs and allowed to cool. When this mixture is remelted, 66 2/3 lb. of tin is added, making a total of 100 lb. of metal ready for use. The average mileage during 1911 obtained from this babbitt in GE-67 armature bearings was 45,174 miles. This average includes all bearings removed on account of accidents or other causes not due to natural wear. The GE-88 axle linings averaged 91,457 miles in the same year.

Bearing Metals in Richmond.—The Virginia Railway & Power Company, Richmond, Va., formerly used for its armature and axle bearings a tin base metal which proved unsatisfactory as the bearings broke frequently before the metal was worn away to any considerable extent. The old metal ran from 12,000 miles to 26,000 miles in the armature bearings and 11,000 miles to 19,000 miles in the axle bearings. It has since been replaced by a bronze bearing composed of 77 per cent. copper, 15 per cent. lead and 8 per cent. tin. These new bearings run more than 50,000 miles. This composition costs 4 cents to 5 cents per pound more than copper, but whatever scrap is left has the same value as copper. The net cost of the alloy varies between 5 cents and 6 cents per pound for the material used. It may be of interest to add that all armature bearings are bored with a self-centering machine and afterward rolled under pressure. This gives a remarkably smooth finish, and thereby tends to increase the life of the bearing since, at the start, there are no inequalities in the surface.

Bearing Composition for Armatures and Journals.—A railway which uses the same tin-base metal for armature and journal bearings has found the following composition a very satisfactory one: Tin, 96 parts; aluminum, 8 parts; copper, 4 parts. New ingots and scrap removed for the first time are used exclusively for armature bearings. After the armature bearings wear out the metal is remelted for journal bearings and for journal-bearing liners until it is finally scrapped. No mileage records are kept of the journal bearings, but in motor bearings this babbitt metal has shown a life of 48,000 miles.

Removing and Replacing Motor Bearings.—Several types of motors, including the Westinghouse 12A, 93A and 101B, have pressed-in bearings. At the Hartford shops of the Connecticut Company such bearings formerly were replaced by using a sledge hammer, but the latter practice has been discontinued as it sometimes caused the breakage of the bearings. The bearings are now removed and replaced by the aid of a home-made air press which consists principally of an old car cylinder, the frame of a Westinghouse No. 49 field press upon which the cylinder is mounted, a gage, valve handle and the necessary piping. Air at 70 lb. to 90 lb. pressure is available for this service, but it has been found that for general purposes a 16-in. cylinder should be used in place of the 10-in. cylinder. In operating this press metal blocks, rings and even trolley wheels are used between the bearings and the piston to insure



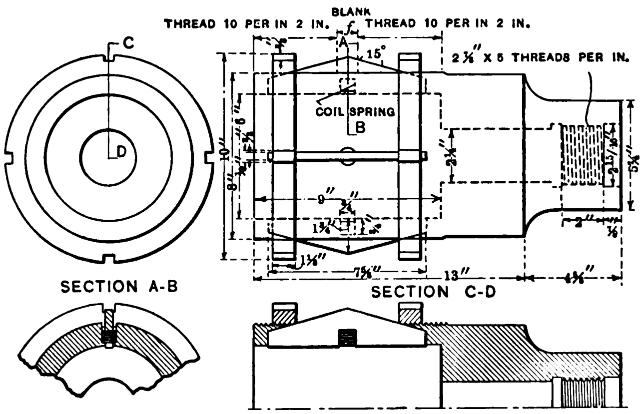
Scraping an axle bearing on a shaper, Hudson and Manhattan shops.

uniform distribution of pressure. This air press is also used for inserting bushings in compressor motor bearings and for similar work. (The Brooklyn Rapid Transit System uses a screw-press for the same purpose.)

Cutters which are graded to 1/64 in. are used to insure the absolutely correct diameter of finished armature and axle bearings when the bearing is being centered in the lathe. Other cutters are used to finish the face of the bearing at the same time.

Adapting a Shaper for Planing Journal Bearings.—For some time the Hudson & Manhattan Railroad has adapted a shaper at its Jersey City shops for scraping out babbitted journal bearings, as shown in the accompanying illustration. The planing disks used consist of scrapped axle metal, which was stamped to shape by means of a steam hammer. The back of the disk is perfectly flat, but the front has its circumference raised slightly in order to obtain a cutting edge for the removal of the babbitt. The disks are made in two sizes, one of 5 in. diameter for the 5-in.×9-in. motor-truck journal bearings and one 4 1/4 in. diameter for the 4 1/4-in.×8-in. trailer truck journal bearings. The cost of the cutting disks is, of course, practically nothing. At the same time the work of scraping out the babbitt is greatly facilitated because the disks cut the entire width at once. In practice it has not been found necessary to run the shaper more than a dozen times to surface a bearing completely.

Chuck for Boring Bearings.—The accompanying drawing shows the details of a chuck, which was designed principally for boring split bearings, as built by F. J. Stevens, then master mechanic of the Lackawanna & Wyoming Valley Railroad, Scranton, Pa., and now master mechanic



Detail of motor bearing chuck.

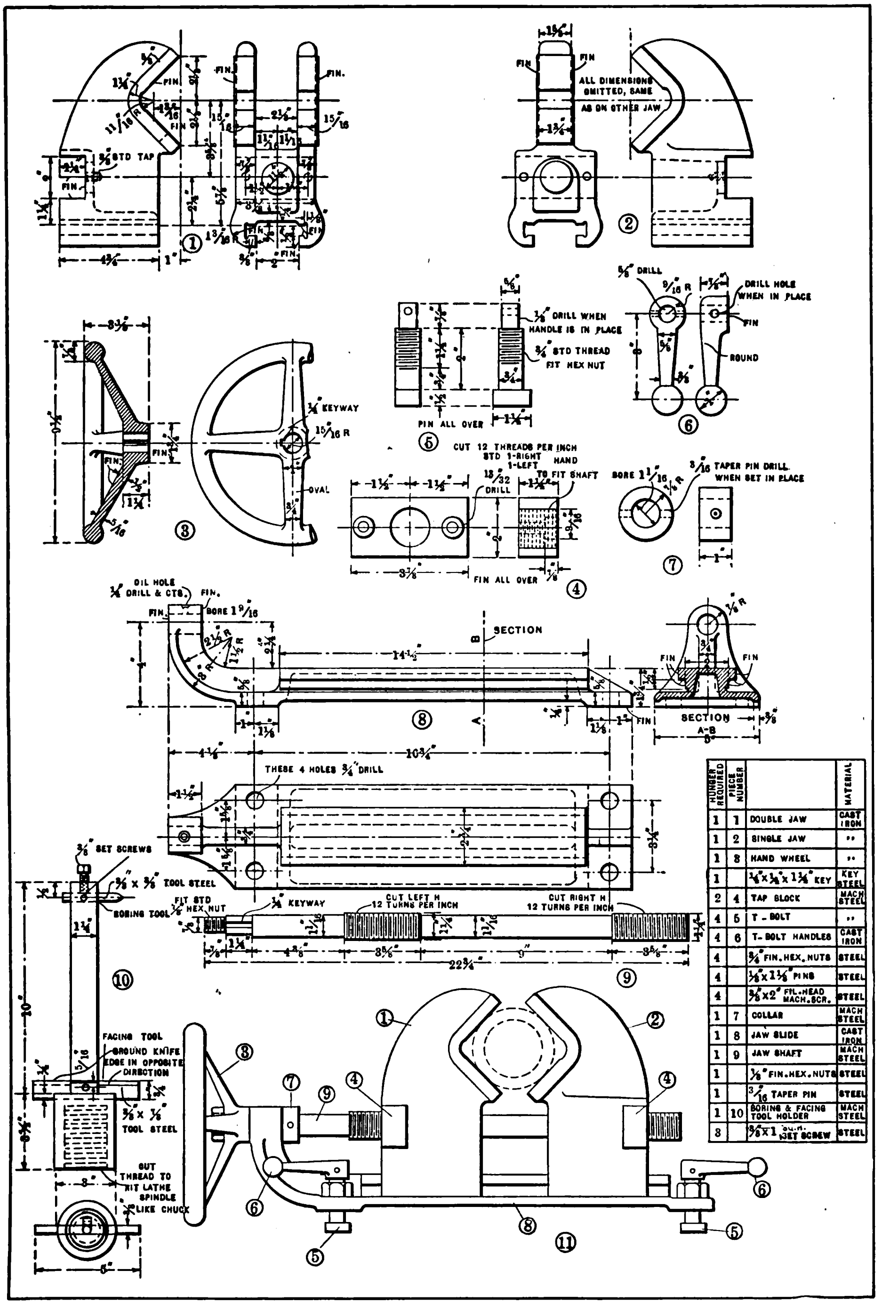
of the Ft. Wayne & Northern Indiana Traction Company. The old way of boring these bearings was to place a clamp on one end before putting the bearings in the lathe chuck. After the bearings were in the chuck some time was required to line them up properly before the cuts could be started. Now the bearings are placed in the chuck and tightened with two ring-nuts. The bearings are bored absolutely true both as to center and end or face, while the work itself is done in less than one-half the time required by the old method.

The chuck consists of a cast-iron cylinder, one end of which is of a size that can be threaded to fit the lathe spindle and the other large enough to admit the bearing. First the casting is put in the lathe and the threads are cut for the spindle, whereupon it is put on the spindle and the remaining machine work finished. In this way the chuck is made absolutely true. After this four slots are cut 90 deg. apart for the jaws and then threaded from each end toward the center with right-and left-hand threads for the two ring-nuts. The ring-nuts are also slotted on the quarter to permit the use of a spanner wrench for tightening. The inner side of each ring-nut is tapered to fit the taper of the jaw. A recess is cut in the jaw (section *A B*) and cylinder to admit a coil spring. This spring serves to hold the jaw in place as well as to release the grip on the bearings when the latter are finished and the ring-nuts are released.

This chuck can be used also on solid bearings of any size that can be put in it. The taper of the jaws can be made to fit the conditions. The range of the device for split bearings is limited by the size of the collar on the end of the bearing. To insure an absolutely true face on each half of a split bearing it is necessary to have something with which it can be lined up and placed in the same position in which it would be on the motor. The chuck is a great labor saver where there are many bearings to bore, since it saves time in truing up bearings and the grip is tight enough to admit the taking of deep cuts up to the finish cut. The work can be concluded with a light cut at a high speed, as there is no danger that the bearings will become loose or that the chuck will be thrown out. The dimensions of the chuck can be varied to suit conditions.

Lathe Attachment for Boring and Facing Armature Bearings.—Many electric railway shops do not realize how much the life of an armature bearing can be lengthened if it is properly faced and bored when first placed in service after babbitting. Generally the bearings are put into the lathe for centering and lining-up by hand with a piece of chalk. This method not only requires the services of a good machinist, but also at least half-an-hour's time. With the attachment shown, however, the same work can be done with absolute accuracy in no more than four minutes.

The accompanying detail and assembly drawing shows the apparatus with dimensions to fit an 18-in. lathe. The same idea, of course, can be carried out for other sizes. As the drawing is so complete it is not necessary to explain every detail, but a little advice on a few points may not be out of place. Piece No. 4 must be fitted after the rest is assembled and the thickness will have to be planed until the threads will come in position to set the jaws in the correct center. To do this right it is best to take a 3-in. or 4-in. truing shaft, place it between the centers of the lathe and set the jaws against it. This will show how much must be planed off from piece No. 4. The T-bolts fit into the grooves on the carriage slide of the lathe. Besides these screws, there should be one 1/4-in. dowel pin on each slide to get the apparatus in line on the lathe. The dowel pins should be fastened to the jaw slide No. 8 and the holes to receive them should be drilled in the slide on the lathe. No. 10 is the boring tool, which fits the chuck threads on the lathe spindle.



NUMBER REQUIRED	PIECE NUMBER		MATERIAL
1	1	DOUBLE JAW	CAST IRON
1	2	SINGLE JAW	"
1	3	HAND WHEEL	"
1		¼"x¼"x 1¼" KEY	KEY STEEL
2	4	TAP BLOCK	MACH STEEL
4	5	T - BOLT	"
4	6	T- BOLT HANDLES	CAST IRON
4		¾" FIN. HEX. NUTS	STEEL
4		⅛"x 1⅛" PINS	STEEL
4		⅜"x2" FIL. HEAD MACH. SCR.	STEEL
1	7	COLLAR	MACH STEEL
1	8	JAW SLIDE	CAST IRON
1	9	JAW SHAFT	MACH STEEL
1		⅛" FIN. HEX. NUTS	STEEL
1		³⁄₁₆" TAPER PIN	STEEL
1	10	BORING & FACING TOOL HOLDER	MACH STEEL
3		⅜"x1" SQ. H. SET SCREW	STEEL

Assembly and details of lathe attachment for facing and boring bearings.

Boring is carried out thus: Adjust the bearing with the large end toward the left or spindle on the lathe and fasten with the hand wheel. This will instantly bring the bearing in line and in center. Then set the tool at the end of the boring bar for a rough cut about 1/16 in. less than the final cut. Set the feed in the carriage and run the tool through from left to right. When through, stop the feed and run the carriage by hand over to the right until the facing tool strikes the bearing. Then press gently and the tool will cut the babbitt in thin ribbons from the bearing until the desired size is obtained. Then set the tool at the end of the boring bar to the exact size, set the reverse feed and run through from right to left. When through, adjust the carriage by hand so that the boring tool will take off the edge. This completes the bearing.

Non-babbitt Bearings.—No babbitt is used in any of the bearings made at the Decatur shops of the Illinois Traction System shops, and excellent mileage results are credited to the care in manufacture and the mixture that is used. This mixture is similar to that used on the Pennsylvania Railroad for the better class of bearings. It consists of 30 per cent. lead, 68 per cent. copper and 2 per cent. tin. In case the mixture includes scrap brass of known composition the quantity of tin is increased 3 or 4 per cent., and the lead is reduced in proportion. This bearing metal has a light bronze color. It is comparatively soft but very tough. These qualities reduce the labor cost of turning and boring the bearings. The lathe used for turning and boring operates at 300 r.p.m., and GE-73 armature bearings are bored and turned for 15 cents each.

The work of finishing the bearings has been greatly facilitated by the use of an expander mandrel. This mandrel is made from a hollowed piece of shafting slightly coned and of sufficient length to extend through the longest bearing. The large diameter of the mandrels, which are made special for the different sized bearings, is about 1/100 in. larger than the finished inside diameter of a bearing. The tapered portion of the mandrel has been slotted with 1/8-in. longitudinal slots at intervals of 1 in. throughout the entire circumference. The bearing when ready for turning is slipped on the tapered end of the mandrel, then forced to a secure position and then the whole is inserted in the lathe.

The master mechanic says that since using this bearing formula he has not had a broken bearing. An example of the service obtained from this bearing metal is found in armature bearings of some large motors on an old sleeping car which makes a 200-mile run from Springfield to St. Louis and return with very few stops. These bearings operate at high unit pressure and formerly it was necessary to replace them at intervals of two days. As manufactured of the new metal, these bearings now require changing only on thirty-day intervals.

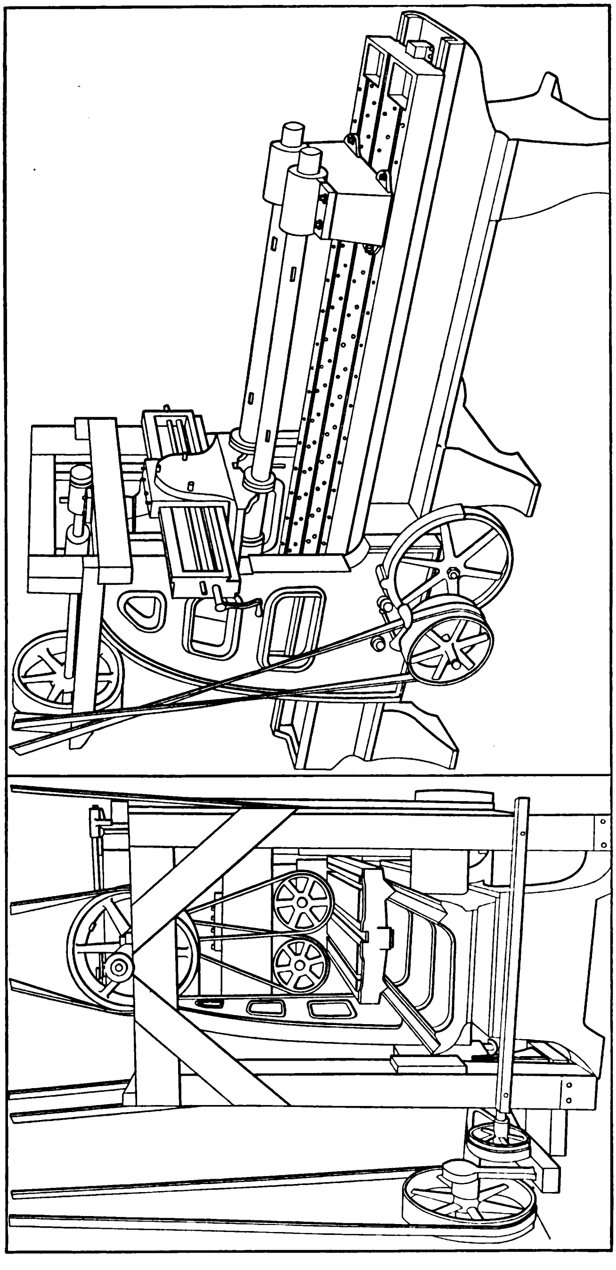
The simple employment of this bearing metal formula was not all that was necessary to obtain the good service. It required considerable experimenting before the exact time of adding the tin and lead was determined, and it was found that a great deal of stirring was necessary at the time the metal was being poured. Besides the two men engaged in carrying the ladle and pouring, a third man is continually stirring the hot metal. This keeps the three component metals thoroughly mixed and allows them to amalgamate properly when cold. The copper is put in the crucible first and allowed to melt. When the melting point of the copper is reached the tin is added and then the lead.

The use of a solid brass bearing is to a certain extent novel and the master mechanic explains its employment on the Illinois Traction System in this way. In a GE-73 pinion end bearing there is a total weight of 17 1/4 lb. of bearing metal, which costs about 12 cents per pound. If babbitt was used for lining the bearing, it would amount to between 15 and 18 per cent. of the total weight, and the babbitt would cost approximately 45 cents per pound. The difference in the total cost of material is evident, even though the cost of replacing the babbitt after it has worn through is not considered. The cost of remelting all-brass bearings is no greater than the cost of replacing the babbitt lining when the labor and materials are both considered.

Boring Motor Bearings on a Converted Planer (By H. D. Allen).—The Portland Railroad division of the Cumberland County Power & Light Company, Portland, Maine, had during 1912 a number of motors which were worn so badly in the armature and the axle-bearing seats that it was impossible to keep the bearings tight, but otherwise they were in good condition, so it was decided to rebore the motor shells and put in larger bearings. As the company did not believe that there was enough of this work to warrant the purchase of a special machine, one of the company's standard planers was fitted up to do the work at a cost less than $100 for both labor and material. All of the work of conversion was carried out by the shop force.

The converted machine was a 34-in. planer which was idle part of the time, and this was equipped with two boring bars made out of old axles. A special casting for a head-stock was made up and bolted to the regular planer head by the bolts that ordinarily fastened the swiveling tool carriage to it. The end thrust of the bars was taken care of at the headstock, and at the other end the bars were left free where they were supported in bearings bolted to the platen.

The motors which were to be bored were bolted to the platen by forms suitable for each different type, thus establishing the proper relative height of the bars. The bars were made adjustable laterally to permit of their being set any required distance between centers, and each bar was fitted with two cutters in order to get at all four holes in



Converted planer: Rear view, showing drive, and side view, showing boring bars, bearings and headstock.

the motor without moving it, thereby insuring perfect alignment. Both holes in one end of the motor were bored at the same time. The bars were made 3 1/2 in. in diameter, and the bearings made very heavy to eliminate all vibration. A wooden frame was built over the planer bed at the rear of the housing so as not to interfere with regular planer work in order to support a 1 15/16-in. shaft running parallel with the boring bars. This shaft was run by a quarter-turn 5-in. belt from the regular counter shaft, and the boring bars in turn were belted to this shaft with 4-in. belts. The proper feed for boring was obtained by moving the planer bed very slowly by means of intermediate pulleys and belts running from an auxiliary counter shaft near the floor at the rear of the planer to the driving pulley on the side of the planer. This introduced two reductions in speed between the regular floor counter shaft and the driving pulley. The regular planer belts were left on all the time but were kept on the loose pulleys by locking the automatic reverse handle in the center.

To change from boring feed to the regular planer stroke it is only necessary to throw off the feed belt and unlock the reverse handle. When the tailstock for the boring bars is removed and the headstock is replaced by the regular tool carriage the machine is ready for use as a planer. In refitting the motors the old dowel pins were done away with and a 3/8-in. key was substituted. To cut the ways for these keys a splining tool was put in each boring bar in place of the regular boring tool, the belt from the auxiliary counter shaft was thrown off and the bars were locked so they could not turn. The planer was then operated in the usual way, the motors being left in the same position that they were in when being bored, thus making all keyways perfectly true. This arrangement made a most satisfactory splining attachment. With the converted planer a Westinghouse 68-C motor can be bored and the keyways cut in four hours.

A Standard Method for Rebabbitting Bearings.—The mechanical department of the Cleveland, Painesville & Eastern Railroad Company, instead of leaving the procedure followed in babbitting bearings to the individual ideas of the workman, has prepared a standard set of instructions to be followed in doing this work. The instructions are as follows:

"Prepare the shell by melting out all the old babbitt and chip and file the edges of the lubrication holes and oil groove recesses, leaving them clean and smooth; then heat the shell sufficiently to drive off any moisture. Rub the surface to be tinned with a cloth saturated with a zinc chloride soldering solution. Coat any machine part of the shell not to be tinned with a thin mixture of graphite and water. Dip the shell thus prepared in a pot of a half-and-half solder which should be kept at a temperature between 315 deg. C. and 370 deg. C. Leave the shell in the solder until it is just hot enough for the solder to run off, leaving a thin coating. Remove the shell from the pot and thoroughly rub the surface to be coated with a swab saturated with the zinc chloride soldering fluid, making sure that all parts have an even coating. Rub the tinned surface with clean waste to remove any oxide or other foreign matter and brush the graphite from the untinned parts. The mandrel should be large enough to leave after babbitting at least 0.020 in. for finishing. Close the lubrication holes with a cylindrical piece of sheet iron, pouring them solid with the lining, and then clean them out afterward with a hot iron. The temperature of the blocks at the pouring should be the same as that of the shell. The babbitt should be kept at a temperature between 350 deg. C. and 475 deg. C. Dip the metal from the bottom of the pot to insure thorough stirring. To avoid pocketing air pour in a steady stream, about 3/16 in. in diameter, directly down around the mandrel. Perform all operations from tinning to pouring inclusive as rapidly as possible, not allowing the bearing to cool. Blow holes should be sealed with a hot soldering iron, using the same babbitt. Remove the babbitt from the lubrication holes with the hot iron, file the edges smooth and clean out the oil grooves. Finish bearing in accordance with design."

The use of this process has been followed with excellent results on the road in question.

IX

CURRENT COLLECTING DEVICES

Trolley Wheel Formula.—The Columbus (Ohio) Railway & Light Company uses a special formula for trolley wheels. It is 90 per cent. copper and 10 per cent. tin. A mixture consisting of 25 lb. of copper to 1 lb. of zinc is employed in the manufacture of the lugs used on switchboards.

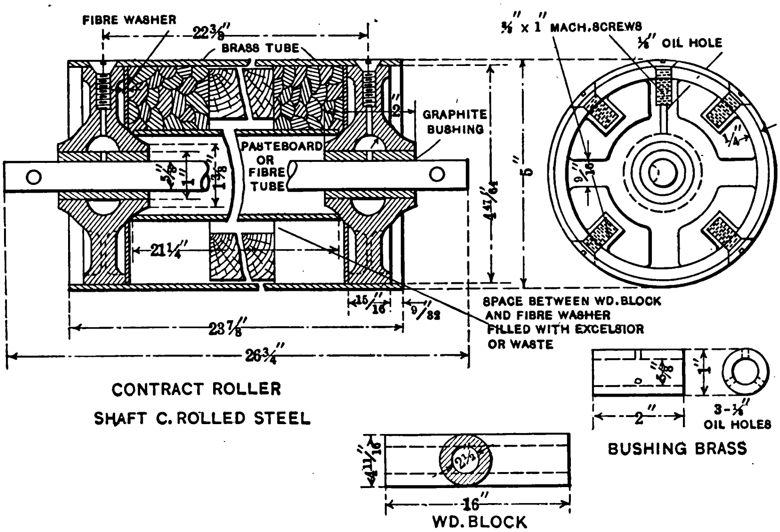
Trolley Wheel Manufacture at New Orleans.—In the manufacture of trolley wheels by the New Orleans Railway & Light Company six wheels are cast at one time. The mixture from which they are poured consists of 89 per cent. copper, 1 per cent. antimony and 10 per cent. tin. Old commutator segments are used in the casting of trolley wheels. The service records of this company show that, considering all of the trolley wheels in use on the entire equipment of rolling stock, the average has a life of 7300 miles. The wheels as manufactured at this shop are fitted with 1/2-in. graphite bushings.

Atlanta Trolley Wheel Practice.—The trolley wheels of the Georgia Railway & Electric Company, Atlanta, are made of 89 parts copper, 10 parts tin and 1 part antimony, are giving an average life of 5000 miles at a cost of 15.8 cents per 1000 miles. The wheels are oiled nightly at the top of the car. In 1908 the total cost for all current-collection labor and materials, namely, wheels, harps, poles, washers, etc., from the base up, was only 19 cents per 1000 miles. The trolley bases are kept at a tension of 15 lb. to 20 lb. The trolley wheels and many other brass and iron parts are made in the company's own foundry.

Trolley Wheel Practice and Casting Formula at Boston.—The Boston Elevated Railway Company has been remarkably successful in securing low trolley maintenance by the use of a light trolley harp and wheel. The total costs of wheels, harps, poles and trolley bases was given at not over $2100 per annum for over 40,000,000 car-miles by Paul Winsor, chief engineer of motive power and rolling stock, at the 1909 convention of the American Street & Interurban Railway Engineering Association. The company feels that to maintain perfect contact between the trolley wheel and the wire it is very desirable to make the wheel and outer end of the pole as light as possible, and on some of the heaviest equipment better service has been obtained from a 4-in. wheel than from larger wheels of the same chemical composition. The company uses a 12-ft. pole of steel, weighing about 23 lb., including the wheel.

The company endeavors to obtain spring in the pole at the upper end, so as to absorb shocks and inequalities in the wire. A very light harp is used with the 4-in. wheel, and the latter is now standard practice for the entire surface system. The bushing on the 4-in. wheel is fitted with a 1/2-in. spindle in place of the 5/8-in. spindle used on the 5-in. wheels. The company does not consider it economical to use large wheels on surburban lines and later transfer them to its urban service. All the wheels used in Boston are made by the company after its own formula, which is as follows: Copper, 91.08 per cent.; tin, 6.60 per cent.; lead, 0.20 per cent.; zinc, 1.95 per cent.; phosphorus, 0.17 per cent.

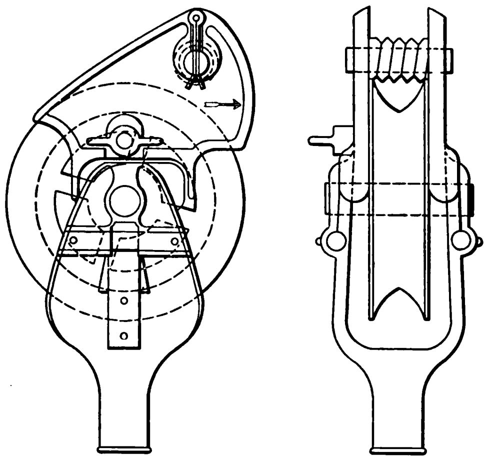
The Roller Trolley.—The adoption of the roller trolley and pantograph on several recent heavy-traction, high-tension, direct-current lines



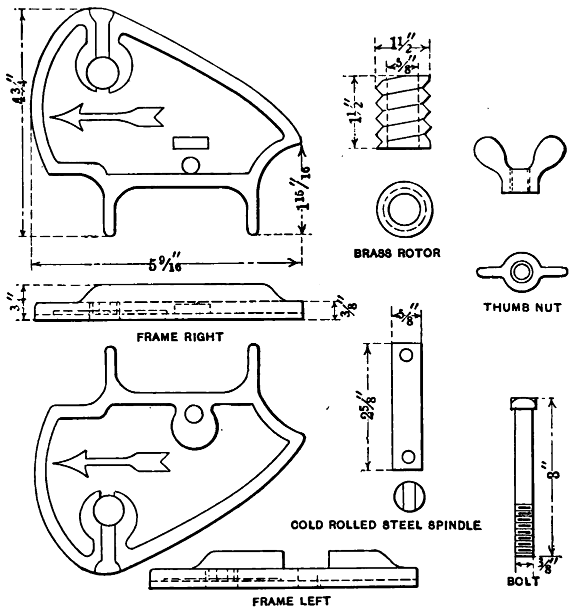
Roller trolley, Key Route, California.

makes a short account of the construction of this roller of interest. It was developed and used on a large scale first on the Key Route cars in Oakland and Berkeley, Cal. On these lines trains of six or more heavy cars run at high speeds with an ordinary trolley voltage, and this made necessary a current collector which would have greater capacity than the ordinary trolley. Since the first roller trolley was adopted on that line several improvements have been made, and the accompanying engraving shows the latest type of Key Route trolley.

The roller is mounted on a pantograph frame and weighs, complete with spindle, 28 lb. The wearing surface is a tube of non-arcing brass, supported on a wooden roller. The height of the trolley wire above the head of the rail varies from 14 ft. 6 in. to 22 ft., yet, owing to the pantograph construction, the pressure of the roller against the wire is kept practically constant at about 34 lb. The average mileage of the rollers is 55,000. The cost of manufacture on a large scale is $6.62 each.



Assembled rotating spiral sleet cutter, Cincinnati.



Details of rotating spiral sleet cutter, Cincinnati.

A Rotating Spiral Sleet Cutter.—Practically all the cars of the Cincinnati Traction Company have been equipped with the home-made sleet remover illustrated. The design of the sleet remover follows, to a certain extent, the usual form; but the method employed for breaking up the sleet and removing it from the trolley wire is novel. The device consists of a cast-steel harp applied to the trolley pole by passing a 3/8-in.×3-in. bolt through the opening between the spokes of the trolley wheel, and is clamped in position by means of a thumb nut. A spiraled brass rotor, supported on a 5/8-in. cold-rolled steel spindle, is inserted in the bearings provided in the harp. The spindle is held in position in the harp by cotter pins.

The principle employed in removing the sleet is first to crush the ice and then to remove it by vibrating impacts. The wire is forced to the side of the brass rotor, which in turn forces the wire out of the groove suddenly, throwing it back toward the center of the harp. Owing to its small diameter the rotor revolves at an extremely high speed when the car is under way. The constant pounding action of the wire against the rotor as the wire slips from the inside face of the harp to the center of it crushes the ice and the vibrating impacts shake the ice from the wire.

Repairing a Trolley Retriever.—It is a dangerous job to take a Knutson retriever apart when the tripping attachment is bent or broken and the spring is wound. To prevent accidents, make a wooden box with a slot to come even with the cap screws. There are four cap screws which hold the heavy spring box in place. Remove one of these screws on each side. Then place the wooden box over the retriever so that the remaining screws can be reached through the slot with a wrench. When the last two screws are removed the spring will unwind inside the box without any danger to the operator.

Trolley-stand Repairs.—On many electric roads a badly worn trolley-pole bearing means the renewal of the bearing and pin. But at Cincinnati a method of repair has been devised which eliminates this necessity. The worn trolley-stand bearings are reamed out and the pin turned down until it is true. This provides sufficient space to insert a set of 1/4-in. case-hardened cold-rolled steel rods which have been turned true, thus making a roller bearing out of a plain bearing. The bearing is inclosed by a large washer and stud bolt screwed in the top of the trolley bearing pin. This method of repair provides not only a better bearing but one that requires less attention and oil.

Trolley-adjusting Device.—A simple device used by the Chicago City Railway Company for obtaining uniform tension between the trolley wheels and wires consists of two wooden rods with a spring balance hooked between them. On the end of the upper rod is a hook which is inserted in the trolley harp. Another hook on the lower rod fits the end of the car hood, and thus the device serves to hold the trolley wheel at the regular operating height. It is the practice to keep the trolley base spring so adjusted that the wheel bears against the wire at a pressure of

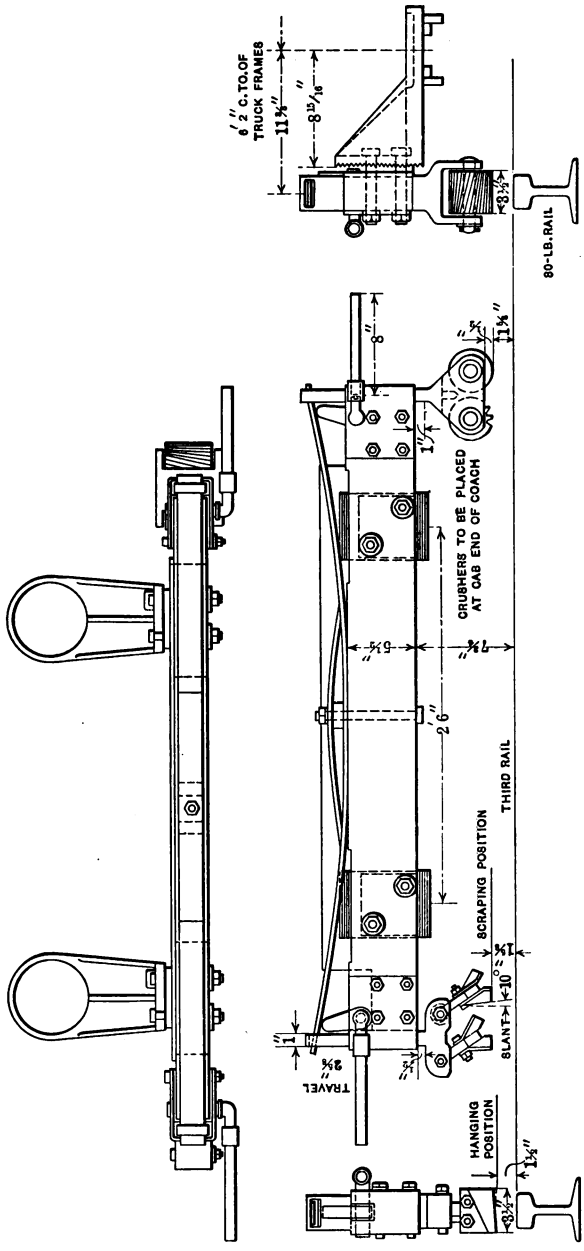
22 lb. When using this simple device the workman can stay on the car and observe the tension while he adjusts the springs.

Truss-supported Trolley Bases at Mobile.—S. M. Coffin, master mechanic, Mobile Light & Railroad Company, has equipped the single-truck cars of that company with special bridges to support the trolley bases. Thus the roof of a car is not only protected from undue strains, but the noise within the car is minimized. The "trolley board" or truss on which the trolley base is mounted comprises two pieces of wood 2 in.×6 in. in section at the center and sized to 1 1/4 in.×6 in. at the ends. These pieces are trussed from end to end with two 5/8-in. rods. The wooden pieces are held about 4 in. apart by spacing blocks and are connected to the truss rods by two queen posts placed about 18 in. from the center. This combination of wood and steel trolley plank is in turn supported only at its ends, and therefore the load of the trolley base is entirely removed from the center of the car roof.

An iron saddle extending over the width of the monitor carries two rubber cushions supporting the trolley board. Two through bolts at each end securely fasten the trolley board to the roof, and the tightening of the nuts on these bolts compresses the rubber cushions so that the trolley board holds the trolley base securely in place. The cost of these trolley boards is small and the resulting saving in repairs to the roof is said to be quite marked.

Telltale for Third-rail Shoe Tripper Signal.—The Hudson & Manhattan Railroad, New York, has installed at its Jersey City shops a signal tripper. This tripper, which is attached to one of the rails, consists of a metal bracket on which a shimmed square plate is carried. Every car which leaves the shops for operation is obliged to pass the point where this tripper is installed, and if the tripper of the automatic stop mechanism on the car is too low it will, of course, be intercepted by the adjustable plate and bring the car to a stop.

Renewal Plate for Third-rail Shoe.—The Central California Traction Company, whose line connects Stockton, Cal., with Sacramento, Cal., was one of the first 1200-volt lines to be built in this country and the first to use a 1200-volt third rail. An underrunning shoe of the usual type is employed, but to avoid the necessity of scrapping an entire shoe, a wear plate is used. This plate is the invention of W. E. Rose, master mechanic of the company. The plate is of soft steel, 3/4 in.×3 in.×6 in., and is attached to the upper or wearing part of the shoe by tapering copper rivets so that as the plate wears away the rivets also wear down and the plate remains on the casting of the shoe. It has been found practicable on the lines of the Central California Traction Company to wear the plate down to 1/8 in. thickness. It can then be scrapped and a new plate attached at the cost of a few cents.



Plan and elevation of sleet-removing device, Metropolitan Elevated railway, Chicago.

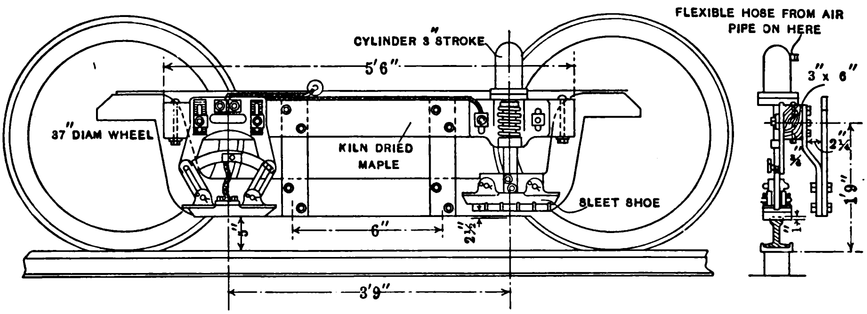
A Sleet-removing Device for Exposed Third Rails.—For a number of years the operating and mechanical departments of the Metropolitan West Side Elevated Railroad Company have been trying to secure a third-rail sleet-cutting device that would efficiently do the work for which it was intended. They have experienced very little trouble in securing a device that would remove sleet in extremely cold weather, but to get one that would do the work well at the time the sleet is falling and when the ice is to a certain extent tough and resilient and adheres to the rail seemed to be impossible. After testing a great many types, both purchased and of their own design, they developed in 1912 the sleet remover shown in the illustration on page 100, and this was found to give best satisfaction under all operating and weather conditions.

The device as shown consists of a piece of oak 2 5/8 in.×5 1/2 in. ×4 ft. 1 3/4 in., at one end of which the crusher rolls are placed and at the other end are the scrapers. The crushing rolls, 3 1/4 in.×3 1/2 in. in size, are right and left spiral-toothed, made of cast crucible steel, hardened, but not machined. These rollers are carried on 1-in.×6-in. steel pins, which are held in place in the steel slide-rod casting by cotter pins at each end. At each end of the oak board is a cast-iron cam and wooden handle, which is used in raising or lowering the rollers or scrapers from or to the working position.

The scraper blades are 1/4 in.×3 3/4 in.×2 3/8 in. and are made of tool steel. There are four of these blades bolted to cast-steel pivots so that they may take the scraping position for either a backward or forward movement of the car. The scrapers are supported on a slide rod provided with the elevating cam similar to the crushers. Immediately inside the guide plates which support the crusher and scraper slide rods are two cast-iron corrugated plates which are used in adjusting the sleet remover for different truck heights and wheel wear. Bolted to the top of the oak insulating timber is an adjusting leaf spring, the ends of which are fitted into slots provided at the top of each slide rod. At first this spring provided 100 lb. pressure at both the crusher and scraper, but now the crusher end pressure has been increased to 200 lb. by adding another leaf to the crusher end of the spring. This sleet-removing device may be either bolted to the third-rail shoe beam or held in position as shown on the plan by means of a casting which is fitted to the car spring seats. A 1/2-in. flashboard made of ash and running the full length of the sleet remover has been inserted between adjusting plates and the oak timber to provide additional insulation.

The device can be applied to the car spring seat for about $14 each, and if applied to the third-rail shoe beam the cost is reduced to about $9. Its life is practically unlimited and requires only the renewing of the scraper blades and crusher rolls from time to time.

Pneumatic Sleet Shoe used by Michigan United Railways.—The Michigan United Railways system includes high-speed lines with third-rail of the open type. Current is collected by shoes riding on the top of a standard section T-rail, which is carried on vitrified clay insulators. The center of the third-rail is 20 in. from the center of the nearest running rail, and its upper surface is 6 in. above the top of the running rails. This road has experienced difficulty in collecting current when the rail becomes coated with sleet. The problem has been solved by the use of a pneumatically operated sleet-cutting shoe designed by W. Silvus, superintendent of equipment, Albion, Mich. The general features of design of the shoe and its method of attachment are shown in the accompanying illustration, which is a plan and elevation of the shoe on the truck.



Pneumatic sleet shoe, Michigan United railway.

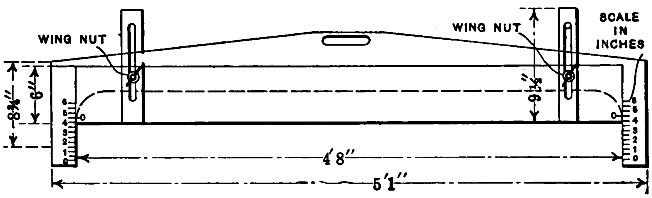
Each car is equipped with two of the pneumatically operated shoes attached to the front of the third-rail beams on the front truck. The interurban cars of the Michigan United Railways are single-ended. The sleet-cutting shoe is of the same design as the regular third-rail shoe, but has four steel cutters set diagonally in its face and cast integral with the body of the shoe. When these cutting edges become worn or damaged they are chipped off, and the shoe is kept in regular service until it is worn out.

The sleet-cutting shoe is mounted on a vertical iron shaft which passes through guides and is attached to the piston of an air cylinder which has a 5-in. stroke. A spiral spring around this shaft holds the shoe off the rail except when air pressure is put on the cylinder to press the cutters against the rail. The air supply is taken from the train line through a 3/8-in. three-way valve and pipes extending under the car to a point convenient for connecting with the cylinder which operates the shoe. This connection between the pipes and the cylinder is made with a 2 1/2-ft. length of 3/8-in. air hose, secured at each end with hose clamps. An ordinary straight valve is placed in each supply pipe to enable the motorman to use one or both shoes as occasion demands.

X

MOTORS AND GEARING

Paving Clearance Gage for Motor Shells.—A gage for use in determining the clearance between motor shell and paving has been used on the Syracuse lines of the New York State Railways. It consists of a wooden frame with projecting legs at each end spaced so that the bottoms of both rest on the rails. The frame has a hand grip on the upper edge for convenience in using. A sliding board, 4 ft. 8 in.×6 in., moves up and down in guides and is clamped to the frame by means of bolts and wing nuts. The inside edges of the frame legs are graduated in inches,



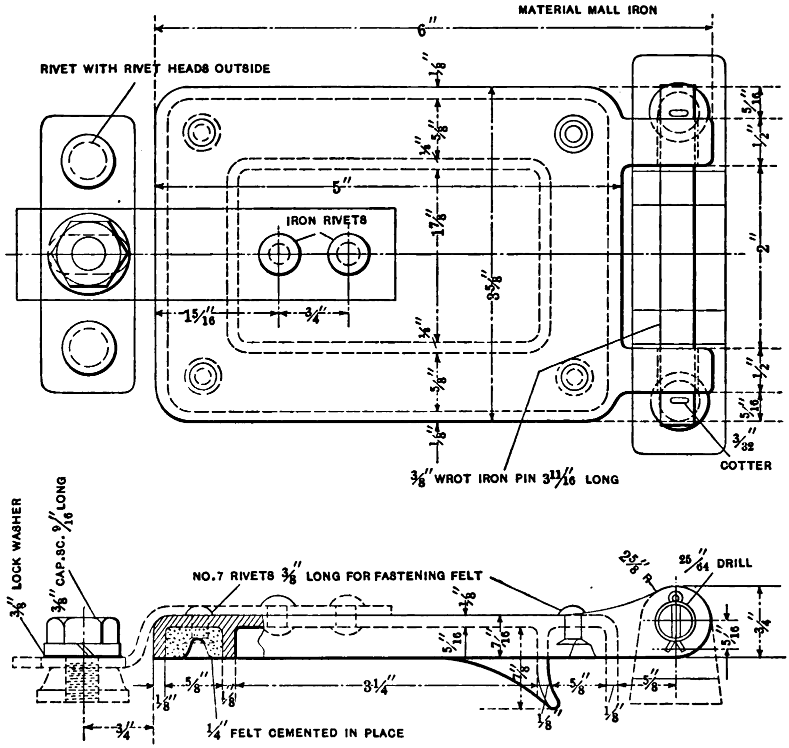
Pavement clearance gage for motor shells, Syracuse.

and marks on ends of the sliding board indicate the average height of the bottom of the board from the bottom of the feet. In operation all that is necessary is to place the feet on the rails and to push the sliding board down as far as it will go. The gage can then be raised for ease of reading the end scales. Dangerously high paving can thus be detected before it does damage to the equipment.

Sealed Grease Hole Cover for Gear Cases.—One of the latest Brooklyn Rapid Transit improvements for increasing the efficiency of lubrication is the practical sealing of the gear cases of the GE-64, GE-80 and Westinghouse 68, 81, 93 and 101 motors. The usual style of cover for the opening in the top half of gear cases is always liable to loosen, thereby causing much noise and eventually ruining the gears through the entrance of dust, oil and water. The first plan was to rivet a sheet-iron cover on all cases in place of the hinged cover. The objection to this was, however, that it would then be impossible to open the top cover for ready inspection. The solution is illustrated in the drawing on page 103. It will be seen that a piece of strap iron was riveted to the gear case cover and that a hole was tapped in the motor shell to take a 3/8-in. diameter cap screw.

The interior of the case can therefore be readily inspected merely by the removal of the screwbolt.

Providence Coil Practice.—At Providence armature coils on being formed are dipped in hot insulating paint, after which the cotton insulation at the ends is stripped off by means of a wire brush to permit them to be tinned. Following this the coils are covered with a layer of tape, a

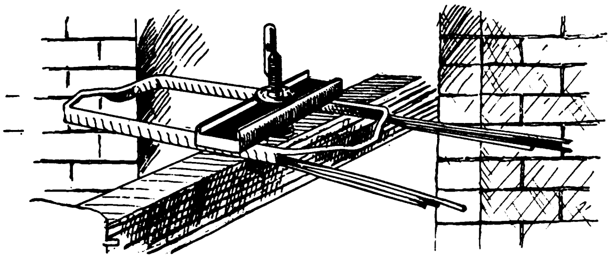


Grease hole cover for West. 81 gear case, Brooklyn.

layer of oil linen, a second layer of tape, and finally are dipped in a cold insulating compound which is of the same composition as the hot compound. The coils are then baked over night in an electric oven. Field coils are filled with special insulating compound as they are wound, which results in an absolutely solid coil when finished. The company does not use vacuum insulation, as it believes that the system which it has followed for the past thirteen years is at least as effective and more economical.

Brooklyn Field-coil Practice.—Field coils which are returned to the shops of the Brooklyn Rapid Transit System for impregnation are first tested as described elsewhere. If found in good condition they are covered with what is termed a "sacrifice tape" of 1 1/2-in. width cotton which is put on as a preliminary to the impregnating process. After the coils have been kept in the vacuum for four and a half hours they are placed for a like period under pressure after impregnating compound is drawn in. When the coils have cooled and hardened, upon removal from the pressure tank, the sacrifice tape is pulled off, thus leaving a smooth coil which is insulated like a new field in the following manner: Put on the leads, apply one layer of friction tape, one layer of cloth 15 mils thick, place canvas cap on the motor side of the field and complete with one layer of 1 1/2-in. waterproof tape and dip in air-drying varnish.

Coil Work by West Penn Railways.—The accompanying illustration shows a convenient method which is used by the West Penn Railways to hold a coil while it is being taped. A crank on a screw projecting upward through the clamp presses the clamp down against the coil.



Holding coil while taping it, West Penn railways.

Coil Practice at Baltimore.—In the shops of the United Railways & Electric Company of Baltimore a brick oven, which is steam heated in winter and electrically heated in summer, is used for making motor coils. New armature coils are first placed in the oven to dry, and then plunged into a compound of 0.865 specific gravity which has been heated by a steam coil to about 90 deg. Fahr. As the warm compound is thin, this treatment thoroughly impregnates the cotton. Gasoline or benzine was formerly used as a thinner, but it was found that these chemicals destroyed the body of the varnish. After impregnation the armature coil is returned to the oven for the final baking. The same compound is used in making field coils except that it is mixed with French chalk to form a mixture of the consistency of molasses. This mixture is then applied to every turn of the field form as the coil is being wound in order to obtain a compact solid mass. After this treatment the coil is thoroughly baked in the oven.

Field Coils on Third Avenue Railway, New York.—Nearly all field coil work of the Third Avenue Railway, New York, is straight overhauling only. After an old field has been stripped it receives one layer of linen tape, two 1 1/4-in. layers of linotape and one layer of 1 1/4-in. canvas tape, upon which it is dipped in insulating compound and baked for twelve hours. After this first drying, the coil is dipped again for a second baking. The oven used is a brick structure, the walls of which are lined with electric heaters near the floor line and furnished with swinging brackets for the suspension of drying fields.

A Field Coil Repair Economy.—The Toledo Railways & Light Company has in service a number of motors equipped with spool-wound-type field coils. Grounds on such coils generally occur between the inside layer of the winding and the shell on which the coil is wound, with the result that the defective coil must be stripped and rewound. In the Toledo shops, as fast as grounded coils of the spool-wound type develop, the spools have been split by taking a cut about 1/4 in. wide out of the center of the spool. The two separate flanges are then applied to the coil after it has been wound on a wooden form.

There are two advantages of this construction. By removing the flanges and the underlying insulation internally grounded field coils very often can be repaired at minimum cost. Drying out of the field coil insulation tends to loosen the winding on the spool, resulting in a shaky coil and ultimately a loose connection. With the split spool the coil can be held securely in place by tightening up the pole piece bolts.

Coil Terminal Anchorage.—During 1909 a new terminal anchorage was designed and put into use on all field coils manufactured at the shops of the Cincinnati Traction Company. Within the following two years not one of these terminals had been destroyed. Provision for attaching a lead wire to either outside or inside terminals is afforded by a tapped and threaded boss against the top of which the lead-wire terminal lug is held securely by a cap screw with a lock washer. The terminal for the outside wire is about 3 3/4-in. long and L-shaped so that it will fit over the side of the coil. A hole is drilled in the angle of the L for insertion of the wire. The inside terminal also is formed to fit the contour of the coil and is provided with a strip of copper which reaches across the width of the coil and is bent around the end of the inside wire before soldering. The main part of each terminal is common brass.

Blowing Out Armatures.—At the shops of the Hamburg (Germany) Rapid Transit System armatures are blown out with compressed air in a closed room instead of the open shop. In regular operation the door is closed and the dust is drawn off directly through an exhaust without the slightest possibility of being blown into the shop.

Commutator Leads at Indianapolis.—In the armature shop of the Indianapolis Traction & Terminal Company pure tin is used in place of solder to fasten commutator leads so that they will not melt out at temperatures which would soften ordinary solder. The leads to Westinghouse 56 motor commutators are fastened in the slots without soldering and excellent results have been obtained by following this practice. The slots in the commutator bars are milled out to a width of 4/1000 in. less than the diameter of the wires. The leads are driven into the narrow slots with a flat tool and the compression of the metal holds them securely in place without the use of solder or wedges.

Some Toronto Electrical Practices.—In overhauling electrical equipment at the shops of the Toronto Street Railway, the motors are first stripped of their armatures, field coils and brush-holders, which are sent to the proper department. The oil cups are cleaned and the motor frame is scraped inside and out. After the interior of the motor casing has been painted with black insulating compound, oiled canvas liners are placed around the permanent pole pieces and the frames are ready for assembling. The cleaned or repaired field coils are next put in place and the magnet plates bolted home with finished steel bolts and hexagon nuts having spring-lock washers. After the motor frames have been bolted together, a gage is inserted between the pole pieces to test for proper spacing. If the distances are found correct, the armature is inserted and another gage used to determine the distance from the pole pieces. When the brush-holder yokes, brush-holder bearings and lubricating equipment have been installed the motor is subjected to a running test for three hours at 40 amp. During the course of this test, the motor is coated with a quick-drying mineral black paint. Finally, the overhauled gearing is lubricated, encased and put on the trucks with the motors ready for service. The motors and gearing are always overhauled in sets of two or four.

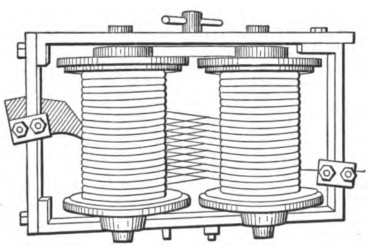
The armatures taken out of the motors are first inspected for bearings and, where necessary, renewals are made with cast-steel sleeves lined with babbitt. Next the entire armature is carefully cleaned, the commutator turned and polished, and the string band inspected or renewed. The commutator is then subjected to the millivolt test from bar to bar. Finally, the armature is given a 1000-volt ground test and, after shellacking, is available for service.

The field coils removed from the motors are placed in a section of a motor frame and undergo a millivolt reading without a magnet. Then a second reading is taken, after a magnet attached to an air-cylinder has been lowered on the coil. If the meter reads up to standard and shows no variation when the coil is under pressure, the outside tape is repaired and the coil is dipped in air-drying compound. In this connection it may be added that in the case of outside-hung motors a great reduction in motor-lead trouble has been attained by boring the motor frames on the axle side and bringing the leads out as near the king bolts as possible.

The following description of the manufacture of a GE-67 armature coil will give a fair idea of the company's practice in coil work generally.

The GE-67 coils are made three at a time, as the coil-former has a triple groove. Before they are taken off the former they are kept to shape by binding them with soft lead straps. Fish-paper strips are then inserted by hand between the coils, after which the coil is tied up and the lead straps removed for re-use. The coil is next dipped in varnish and left to air dry. After drying, the insulation is removed from the ends for a length of 2 1/2 in. The ends are then tinned and covered with web-sleeving. After this the strings are taken off and the sides of the coils are surrounded by fish paper, which is hot-glued on by a small air press. Only the sides are treated in this manner, as they form the part which goes into the slots. The coils are then taped by machine with linen taping, which is applied so that half the next turn always overlaps the preceding one. The coil is then dipped in air-drying varnish and treated with soap stone to make it enter the armature slot easily. The completed coils are stored in closets, according to type, and are marked with the date of manufacture so that the oldest will be taken out first.

Field coils, after winding, are heated for the removal of moisture and then dipped in yellow varnish until the absence of bubbles shows that all air has been expelled. Next the coil is baked over night and then supplied with flexible leads made up of 245 strands of untinned No. 30 rubber-covered wire. One lead is 24 in. and the other 6 in. long. When the leads are soldered on, insulation is begun. The leads, however, are not tied down parallel to the coil until some mica has been inserted between them and the coil. The insulation consists of two double-overlaps (four thicknesses) of glace belting and one layer of insulating tape. The field is then redipped and baked all night. After the second baking, the corners of the coil are reinforced with No. 8 oil duck. The entire coil is then taped with black rubber tape and air dried in varnish to complete the operation.



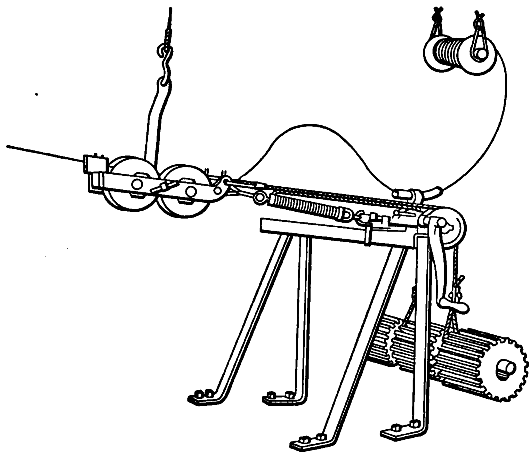
Spools for holding banding wire, Denver & Interurban railway.

Applying Banding Wire.—The following method of applying banding wire to its single-phase motors is used by the Denver & Interurban Railway. For this work the company has installed an automatic tension-regulating device so that the tension on the band wire, while it is being wound on the armature, can be kept continuously at any amount, that usually used being 400 lb. With this device, also, the usual tension clamp, which presses on the wire, is not required. This eliminates the danger of breaking the tinning on the steel banding wire, a fault found with the ordinary contrivance.

The tension-regulating device consists of two grooved spools, each

4 in. in diameter and 6 in. long, held in a frame as shown in the first engraving. The wire is wound back and forth over these two spools, having about twelve turns on each spool. A leather washer fits between the end of the spool and the end plate in the frame in which the spools are mounted, and by means of a screw these end plates can be pressed down on the leather washer. In this way the power required to revolve the spools, and hence the tension on the wire as it leaves the spools is regulated.

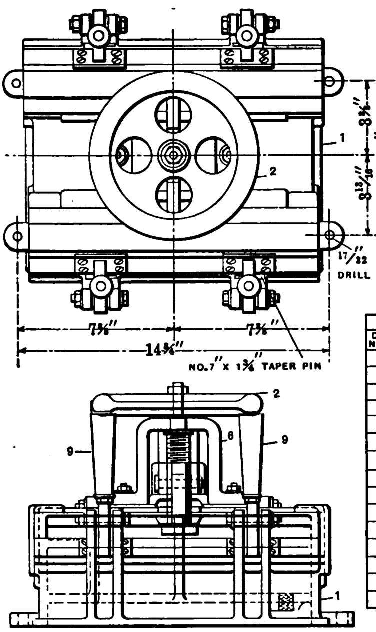
The second engraving shows the method of using the tension device while the banding wire is being put on an armature. The tension device, with the wire wound on it as described, is suspended from above and is

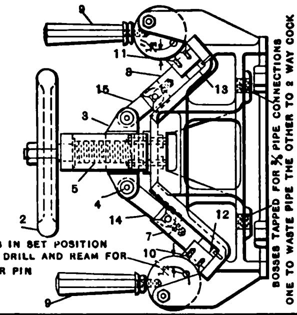


Tension device for banding wire, Denver & Interurban railway.

held at the back by a set of powerful springs to which are attached cords which pass over pulleys and are connected at their lower ends with weights. In this way any variation in size in the wire which would cause inequality in the tension when the wire passes over the spool is taken up. The band wire is fed to the spools from a reel overhead. The tension is usually kept at about 400 lb. instead of the ordinary tension of about 300 lb. When this wire is wound on the armature tin clips are placed under the wire where it crosses each coil instead of under every fourth coil, as formerly. By these means the safe maximum speed of the motors has been increased from 1680 r.p.m. to from 1900 r.p.m. to 2000 r.p.m. and the capacity of the motor has also been increased.

Brooklyn Armature and Commutator Practice.—At the shops of the Brooklyn Rapid Transit Company, after an armature coil has been wound on one of the coil forms, the ends are taped and sleeving is placed on the leads. The coil is then baked in an oven for two hours, after which it is dipped in baking varnish. The coils are then hung up in an adjoining room to drip, after which they are baked for four hours. Upon completion of the second baking the coil is taken to the winding room, where both sides are covered with three thicknesses of cloth, each layer 8 mils thick. This cloth is applied with shellac and covered with fish paper, which is tied on until the shellac is dried sufficiently to retain it. The coils are now ready for the hot presses. The details of one of these presses are shown in an accompanying drawing. In this design a central





BILL OF MATERIAL			
DETAIL NUMBER	NAME	MATERIAL	NO.REQ.D
1	FRAME CASTING	CAST IRON	1
2	BAND WHEEL	" "	1
3	CROSS HEAD	CAST STEEL	1
4	CROSS HEAD PIN	MACH. STEEL	2
5	FEED SCREW	" "	1
6	END BEARING	CAST STEEL	1
7	SLIDE (13¾" LONG)	MACH. STEEL	1
8	SLIDE (14¼" LONG)	" "	1
9	CAM	" "	4
10	CAM SLIDE (13¾" LONG)	" "	1
11	CAM SLIDE (14¼" LONG)	" "	1
12	ADJUSTMENT STRIP (13¾" LONG)	" "	1
13	ADJUSTMENT STRIP (14¼" LONG)	" "	1
14	CONNECTING LINK	" "	1
15	CONNECTING LINK	" "	1

Armature coil press for West. 81 motors, Brooklyn.

screw is used to transmit the pressure of steel plates which bear on the sides of the coil. There are one or more side clamps, depending upon the size of the coil, to secure a uniform distribution of pressure. The presses are steam-heated and water-cooled. Of the sets of four valves used in connection with each press, two are for steam inlet and exhaust and two are for water inlet and exhaust. When the coil has been hot-pressed it is taped and dipped again and returned to the oven for the final drying. The leads are then tinned and the coil is ready for assembling. The use of hot presses has greatly improved the insulating qualities of the coils.

A simple but important improvement in the banding of all surface and elevated armatures is the use of tin binding strips to prevent the loosening of the bands in service. The strips are laid over the banding insulation which is in the bottom of each banding slot. Then the wire bands and clips are installed in the usual manner and the tin strip is soldered to the entire wire band.

When armatures are brought to the Fifty-second Street shops for repairs they are blown out by compressed air, the cleaning being done in a horizontal cylindrical tank. This tank is provided with an exhaust which carries off all dust and dirt.

The commutators of all types of motors are now slotted. The slotter in use for the surface armatures has a slide rest which carries a small swinging frame and an arbor for a circular saw. Means are provided to adjust the machine for commutators of various dimensions. The slotter for elevated armatures is of the reciprocating type and is based on a design used by the General Electric Company. The armature is arranged to rest on a channel beam framework, and two screw posts are provided for height variation with a horizontal screw in each post to make adjustments to prevent end motion. The reciprocating-type slotting saw is belt-driven.

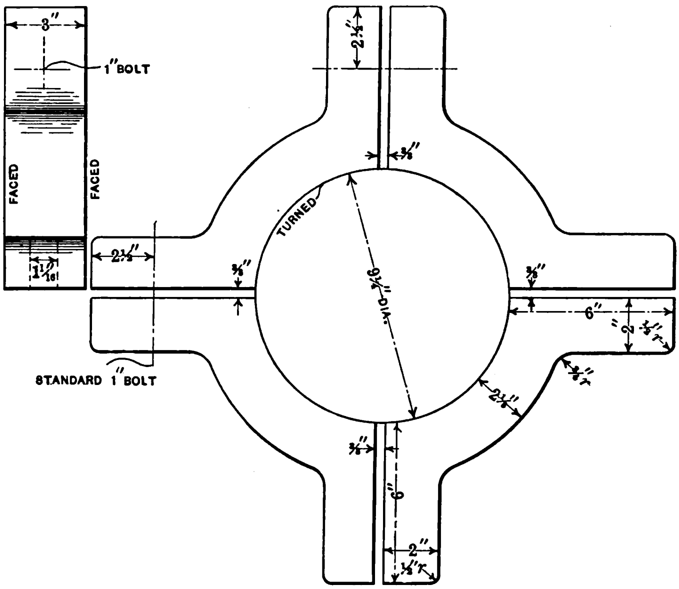
An interesting point in connection with the commutator work is that all nuts are tightened while the cone ring is under pressure so that there is no strain on the threads when the nuts are sent home. The pressure on the cone ring under these conditions varies from 5 tons to 15 tons, according to the type of commutator.

Deep Commutator Slotting at New Orleans.—All new commutators of the New Orleans Railway & Light Company are slotted to a depth of from 1/4 in. to 5/8 in. and the slots are then filled with plaster of Paris mixed with shellac. Before the application of this mixture the copper of the commutator is heated with a gasoline blow torch. The mixture is smeared on with a putty knife and allowed to cool. It is stated that this practice, while avoiding too frequent reslotting of the motor, keeps the carbon dust from packing between the bars, thus avoiding the possibility of short circuits.

Commutator Building at Toronto.—All commutators at the Toronto Railways are made from drop-forged bars, which are assembled in the four-piece clamping plate shown in the illustration. Upon inserting the mica, the bars are squared and the clamps tightened, after which the assembled commutator is placed on a lathe chuck to bore out the bars. The latter are then tested for short circuits. Next, the commutator bars are secured on the commutator core and a second short-circuiting test is made after the removal of the clamps. The commutator is then baked over gas to soften the mica, after which it is tightened again and allowed to cool. Then it is taken to a lathe to have the face turned and the bars slotted for the armature leads. Following this, a third short-circuiting test is made, and the commutator is shellacked at both ends.

Finally, the commutator is pressed on the armature shaft at three to seven tons pressure. The hydraulic press used for this purpose also serves to remove the commutators. No trouble has ever been experienced from loose commutators. They are made with a taper of about 3/16 in. and are held by a jam nut between the oil deflector and the commutator end and by a collar shrunk on with a holding pin or dowel to prevent turning.

Instead of using a milling machine for cutting the bars for the armature leads, the shops have devised a special tool post, which is employed for this work in connection with a cutter wheel on the arbor of a lathe. The



Clamp for Setting up GE–800 Commutators, Toronto.

commutator is set on the tool post, which, in turn, is set on the lathe carriage. The post is furnished with adjustable collars for different sizes of commutators. The teeth of the bar-cutting wheel used in this operation, designed especially for milling copper, are alternately square and diamond shaped. The latter teeth split the copper and the former sweep out the copper dust. These wheels are far superior to the old cutters, which were made with all teeth square. They can mill twenty-eight commutators without resharpening, whereas the square teeth could mill only twelve commutators without resharpening. The best record so far made was with two cutters which milled sixty-four GE-1000, GE-67 and GE-80 commutators, in all of which the arrangements for leads are alike. The cutter is not cooled by a drip, but is allowed to run in a pan of water, which arrangement is safer for the attendant. With this device a Westinghouse No. 3 commutator is slotted in 6 minutes and a GE-67 commutator in 15 to 20 minutes. The finishing touches are made with a hand file.

The commutator slotter, used by the Toronto Railway, is suitable for cutting commutators of any size. Both ends of the supporting frame can be moved vertically, and by means of bevel gearing at one end of the commutator can be moved sidewise to handle bars out of true without shaving the copper. Another feature is the quick reverse of the feeding mechanism, which is attained by releasing a spring thumb latch pressed against the feed thread and then drawing back the carriage.

A number of repairs to commutators are made with the commutator in a vertical position. After the bearings have been taken off and both the collar and oil deflector removed, the armature is set with the commutator end up in a floor casting containing an armature pinion. The jam nut is then unscrewed and the mica circle removed, after which the commutator may be readily examined for grounds and other troubles.

Method of Recording Wear of Gears and Pinions (By W. E. Johnson). —The recent introduction of various types of gearing for electric railway

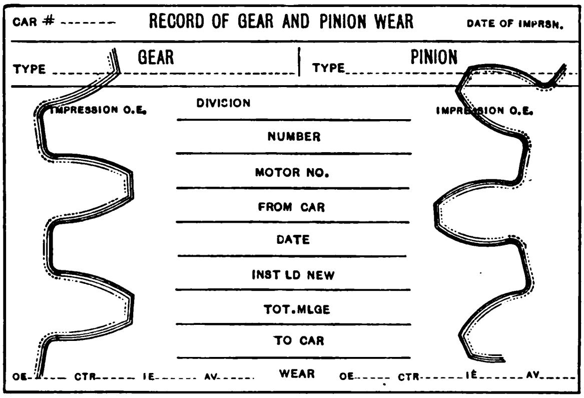
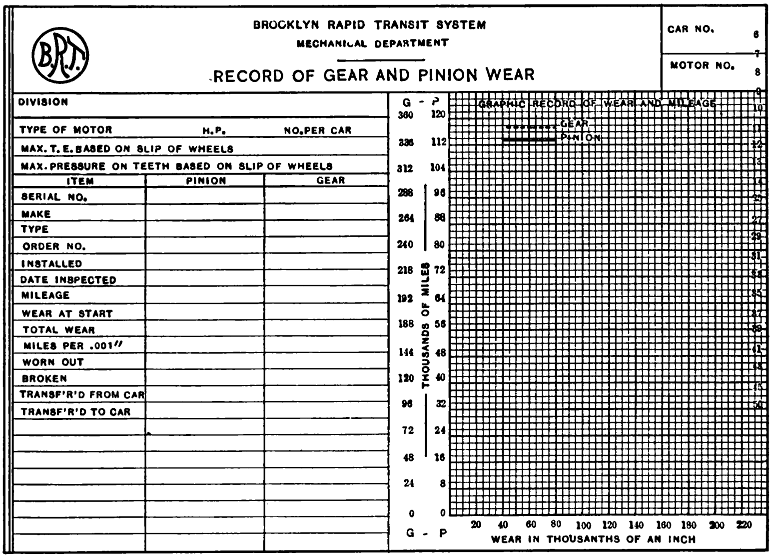


FIG. 1.—Filing card showing impression of gear and pinion teeth.

service, including different grades of treated and alloy steels, means that accurate records will be kept of wear and mileage, and a careful study should be made of them so that the quality and combination best suited to fulfil the requirements of the service may be determined. This is especially important because the cost of these special grades is considerably more than that of the ordinary untreated carbon steel pinions and cast-steel gears which have been used in the past.

The requirements of a system for keeping records of wear and mileage of gears and pinions are, first, that it shall be simple enough to enable the ordinary shop mechanic to obtain and report conditions as to wear readily and accurately, and second, that it shall provide for a convenient and comprehensive record of wear and mileage. To fulfil these requirements the writer devised the system herein described, and it is being successfully used by the Brooklyn Rapid Transit System in connection with extensive trials of various makes and grades of gearing now under way.

At the time of its installation one tooth of the gear or pinion is marked on the end with a prick-punch for identification so that the same tooth can be selected for measurement each time thereafter. Then an impression is taken on a standard 4-in. × 6-in. filing card, specially printed for this purpose, as shown in Fig. 1, by placing the card against the end of


BROOKLYN RAPID TRANSIT SYSTEM
MECHANICAL DEPARTMENT
RECORD OF GEAR AND PINION WEAR

CAR NO.
MOTOR NO.

DIVISION
TYPE OF MOTOR H.P. NO. PER CAR
MAX. T. E. BASED ON SLIP OF WHEELS
MAX. PRESSURE ON TEETH BASED ON SLIP OF WHEELS

ITEM	PINION	GEAR
SERIAL NO.		
MAKE		
TYPE		
ORDER NO.		
INSTALLED		
DATE INSPECTED		
MILEAGE		
WEAR AT START		
TOTAL WEAR		
MILES PER .001″		
WORN OUT		
BROKEN		
TRANSF'R'D FROM CAR		
TRANSF'R'D TO CAR		

FIG. 2.—Graphic record of wear and mileage of gears and pinions.

the gear or pinion teeth and lightly hammering on the back of the card over the outline of the tooth with a machinist's ball-pen hammer. The thickness of the tooth on the pitch circle is then measured and recorded on the same card. This measurement is taken at three points on the tooth, namely, at the outside end, center and inside end. After the car number and other data relative to the gearing have been entered on this card, it is sent to the office of the superintendent of equipment, where the mileage of the gear from the date of its installation is entered and the wear and mileage are recorded graphically on the form reproduced in Fig. 2. This form, which bears complete information as to car number, motors, type of gearing, tractive effort, etc., is kept in a special post binder properly indexed for reference, and as it is printed on a light grade of bond paper it can be blueprinted when occasion requires. The teeth of both gear and pinion of each set of gearing are recorded on the same card and form so that the effect of one upon the other can readily be noted. Records are filed by car number, and impressions and measurements of the gearing are taken each time the car is brought into the shop for overhauling. Thus a progressive record of the wear and mileage is obtained and is always available for reference. From the measurements so taken an average is obtained, and the rate of wear and cost per car mile are computed.

Some may consider it superfluous to obtain impressions of the gear teeth in addition to the measurement of wear because it is of no particular value as a record. However, these impressions have been found very convenient as a reference. Moreover, they provide a quicker means for indicating the condition and give a clearer idea of the wear than could be obtained from the measurements alone. Graphic records of wear and mileage have advantages over other methods in that any variations in the rate of wear are discovered at once, and the results from various combinations are readily noted.

The measurement of the gear and pinion teeth is the most important part in records of this kind, for unless this is accurately done the results will be unreliable and without value in determining the best and most economical type of gearing. The standard commercial instruments for

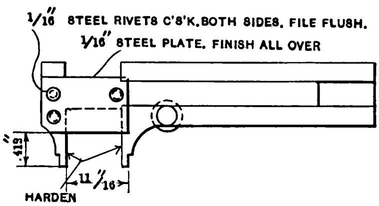


FIG. 3.—Calipers for obtaining thickness of gear tooth.

measuring gear teeth are expensive and require great care and accuracy in reading the results. For example, a vernier or micrometer scale is required in order to read to a thousandth part of an inch, and furthermore such scales measure only the thickness of the tooth, so that to obtain the wear it is necessary to deduct this amount from the original tooth thickness. The instrument devised by the writer is inexpensive and requires no knowledge of vernier or micrometer reading. As shown in Fig. 3, an ordinary sliding caliper, which is provided with a stop plate to give the required distance from the top of the tooth to the pitch circle, is used to obtain the thickness of the tooth. The wear is then obtained directly by inserting a tapered gage between the jaws of the caliper. This gage, which is shown in Fig. 4, is based on the same principle as a tapered screw or wire gage. The zero point represents the new theoretical thickness of the tooth, and the gage is tapered 0.04 in. per inch of length. Full 1/4-in. graduations, with intermediate partial graduations, are provided on one face of the gage, and as each full graduation represents a difference in thickness of 0.01 in., readings to 0.001 in. can readily be obtained with this gage.

The height of the jaws on the calipers will vary according to the pitch and also according to the number of teeth in gear and pinion of the same pitch. Where a comparison in wear between pinions of the same pitch

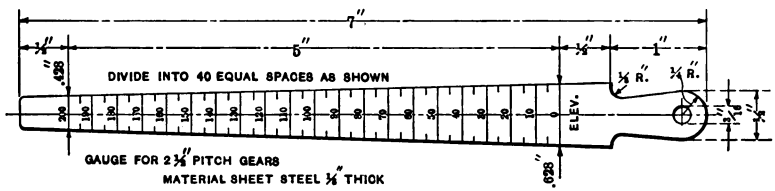


FIG. 4.—Gage for measuring wear of gear and pinion teeth.

but with different numbers of teeth is required it may be desirable to have a set of calipers for each type of pinion. As the difference in reading in such cases would be very slight, however, and as they would at any rate be comparative, one caliper usually is satisfactory for each pitch used.

Experience with Slotted Commutators on Railway Motors (By F. J. Foote).—The Ohio Electric Railway began to slot commutators about 1910. Previous to that time we had a great deal of trouble from flat spots on commutators. A thorough system of inspection had not yet been inaugurated, and the presence of a flat commutator would often be indicated by the opening of the main circuit-breaker on the car when running at high speed. This action of the breaker is almost a positive indication of a flat commutator, since the actual working current required to operate the car is less at high speed than at low speeds or when starting the car. The flat spot causes the brushes to leave the commutator or "jump" at high speeds, and this in turn causes the current to flash over from brush to brush or to jump to the motor case. This flashing over caused the burning up of many brush holders and canvas armature hoods, the grounding of the commutators, injury to the field coils and excessive burning of the circuit-breakers. The worst offenders were the GE-73 motors, of which we had about 136 in use under heavy service conditions.

Just before the time that we began to slot the commutators we replaced about fifteen brush holders per month, at a cost of $7.50 each. Since this was done flat spots are almost unknown, and we do not average one burned brush holder per month. Our trouble with burned canvas heads has been greatly reduced, and our field trouble is about 10 per cent. of what it was formerly. On the whole, it is safe to say that slotting the commutators has been responsible for reducing our total motor troubles at least 60 per cent.

Many railway men do not seem fully to understand that soft carbon brushes must be used with slotted commutators. We have proved this fact by experience. We knew that soft brushes should be used with slotted commutators, but we had one style of armature whose commutator was still giving trouble from flats. As we had no soft brushes on hand that would fit it, we decided to slot one commutator and to try the old hard brushes. After this commutator had been in service for a few weeks we found that the hard brushes had been wearing away the commutator very rapidly. We were obliged, therefore, to discontinue the slotting of these commutators until suitable brushes were secured.

The converse of the proposition stated hereinbefore is also true, namely, that soft brushes are not suitable for use on unslotted commutators. An old motor, which was driving shop machinery, was sparking badly. The commutator had not been slotted, the mica between the bars being extra thick. We tried soft brushes on this commutator, but found that the mica wore out the brushes very rapidly and that the sparking increased, because the brushes were not hard enough to grind the mica even with the copper segments.

Very little trouble will be experienced with flat commutators, if a brush can be found that is just hard enough to keep the mica even with the copper. We had several GE-54 unslotted commutators for which the carbon brush that we were using seemed to be just right, as the commutator rarely showed any indication of high mica or flat spots. This condition, however, would be very difficult to secure and maintain in all cases. Even if it could be done the decreased wear of the commutator and brushes would more than offset the extra cost of the soft brushes and slotting.

In regard to the kind of brushes used, we have never found any brush quite equal to the French brushes, although American brushes nearly as good are now on the market, and in a short time, probably, the American brush will equal the best imported product. One trouble experienced with all makes of soft brushes, but not with the hard brushes, is the excessive wear on the flat faces, due to the abrasion of the brush holders. If the manufacturers of soft brushes can overcome this difficulty, a marked improvement will result. Now we often have to throw away brushes due to looseness in the holders, when otherwise they would be of service for several thousand miles more.

We have tried several methods of slotting. Our first slotting was done on the lathe, using for a slotting tool a hack-saw blade about 1/2-in. long which was set into a piece of steel for a tool holder in the tool post of the lathe. The piece of saw blade was set in such a way that each of the six or eight teeth would cut its share of the mica. A number of commutators were slotted with this device, but it was found that the teeth clogged up very easily.

We next rigged up on our banding machine a circular saw of 1-in. diameter with about sixteen teeth. This saw was mounted on an arbor and driven by a small round bell at about 1500 r.p.m. from a motor suspended from the shop ceiling. The headstock carrying this arbor was mounted on a slide and operated with a hand lever. Arrangements were provided for the vertical adjustment of the saw. This contrivance worked fairly well and was used several months. We found, however, that it was necessary to have a saw that would clean out all of the mica, since if any was left in the sides of the slots it would not break out but would remain in place and cause flat spots. In other words, we were obliged to have several widths of saw to match the various commutators. We also found that the saw would raise a small "burr" that sandpaper would not remove, and the armature had to be put back in the lathe for a very light cut.

We cut the slots a scant 1/16 in. deep. When any repairs are made on commutators it is usually necessary to turn them down to some extent before slotting. As our facilities for handling heavy armatures are not the best, we finally concluded to do the slotting in the lathe, using in the tool post a tool which is just wide enough to remove all of the mica and no copper. In this way the preliminary turning, the slotting and the final light cut can all be made without removing the armature from the lathe, thus saving much time.

Considerable skill is required to get the finishing cut just right. We find that it is necessary to keep the tool very sharp and keen, whetting it often with a small oilstone. If this is not done there is a tendency to drag the copper into the open slots. Our machinist keeps a tool exclusively for this work. We run the commutator at a high speed when turning, and the whole operation of taking the finishing cut after slotting requires about five minutes. No sandpaper is used. It is necessary to go over the commutator with a small hook, made of an old hack-saw blade, so as to pick out any particles of copper that may have lodged in the slots. Our machinist's regular time for doing this work, that is, taking the preliminary cut, slotting, taking the finishing cut and going over the commutator for burrs, is forty-five minutes for a GE-73 bar commutator and one hour for a Westinghouse No. 121, 205-bar commutator. The tool used for slotting is a single point, set well forward and having a large rake.

We find the method last described to be the most satisfactory of all yet tried by us.

Splicing with Silver Solder.—A good electrical shop kink is the butt-end soldering of broken or burned-out wires without removing them from the armature or field coil. If the splice is to be made on an armature coil the damaged wire is raised a little way out of the slot. The insulation is then scraped off for a few inches and the ends of the broken wire are filed off smoothly, after which a piece of wire is cut to fill the gap. One end of the inserted wire is then butt-ended with the armature wire and the ends heated by a gas torch until they are red hot. Upon this a little borax is applied as the flux, and then some silver solder is inserted between the ends. When both splices are completed in this fashion the bare wire is wound with silk, as the latter takes up less space than the tape. After the silk has been covered with insulation the coil is ready to be returned to the slot. During the operation of heating with the torch the adjacent wires are protected by fiber barriers. Field coils also can be spliced in this way, and the same method used to solder the ends of successive reels of wire.

Portable Transformer for Testing Armatures.—At the Homewood shops of the Pittsburgh Railways a convenient mounting has been designed and built for an alternating-current magnet coil testing set, used to detect short-circuited armature coils. The curved pole piece and coil are bolted to the top cross-piece of an ordinary two-wheeled warehouse truck. The iron shoe on the bottom of the truck is bent backward so that the frame of the truck will stand vertically when tipped up. Armatures under repair are mounted on wooden horses, which are of such a height that when the transformer truck is tipped up the center of the pole-piece is exactly opposite the center line of the armature shaft. The armature shop is wired for 60-cycle current incandescent drop lamps over each armature horse and by connecting the testing coil to one of the lamp sockets suitable current is instantly available. Transformers of this kind are frequently mounted on a frame equipped with castors, but the attachment of the transformer to an ordinary warehouse truck makes it a very convenient outfit for transportation around the shop.

Broken Commutator Leads. *Question.*—We operate about 40 miles of interurban road and try to keep up everything in first-class shape but have a great deal of trouble with armature leads breaking off. We have found that some of our armature cores were loose, and this no doubt caused some of the trouble, but we have considerable trouble even with armatures that are almost new and in cases in which we are positive that the commutators and the laminations are tight on the shaft. We have been exceedingly careful in placing the leads in the commutator slots not to hammer or bend them too short back of the commutator, but still have more trouble than we should. We might add that we use a very soft copper wire. Our equipment consists of Westinghouse No. 56 and No. 76

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motors and is operated from both ends of the car. We should appreciate it very much if you would give us an idea as to what is causing the trouble.

Answer.—The most common causes of broken armature leads are loose laminations and loose commutators. In the two types of armatures which you mention the laminations are mounted directly on the shaft and are much more liable to become loose than on a type of armature with spider construction with laminations mounted on it. If the commutator and laminations are tight, the cause of the trouble is probably in the material or method employed in rewinding armatures. When coils are being prepared and placed in the slots the leads are often bent back and forth a number of times, sometimes unnecessarily. Thus, when the corners and ends of the coil are being taped the operator will often bend the leads back to make a neat job of the taping. Then the person who winds the armature is apt to bend the leads back again to get them out of the way while he is bringing other leads down to the commutator. This may start a fracture, which is soon increased in size by the vibration of service conditions. When the repair man is bringing the leads down to the commutator he should be careful to avoid sharp bends. They may make a neater appearing armature, but wearing qualities should never be sacrificed to secure a good appearance. If the operating conditions are such as to produce severe vibrations in the motor parts, it may be of advantage to provide a support for the leads between the end of the armature and the commutator. One method that has given good results on other roads is to fill this space with a mixture of powdered asbestos and shellac, after all leads are in place. This material can be forced in between the leads by the use of a tube fitted with a plunger and having one end drawn out small enough to enter between the leads. All armature coils should be tight in the slots. The repair man should also make certain that the wedges are of sufficient thickness so that the bands will come down tight on them and not be resting on the laminations with a space between the bands and the wedges.

One large road which had a great number of broken armature leads has almost entirely done away with trouble of this nature by shortening the distance that the leads are unsupported. Previous to the change the leads left the coils at the corners and had no support till the commutator was reached. The change consisted of bending the leads farther around on the end of the coil and taping them in so as to shorten the distance to the commutator considerably. On armatures with leads going in opposite directions this cannot be followed to any great extent, but leads going in the same direction can be taped together so as to form a support for each other and make a more rigid construction.

Sparking at Commutators. *Question.*—We are operating a twenty-minute railway service with single-truck cars, equipped with GE-1000 motors and K-10 controllers. These cars are single ended and have a 5 per cent. grade to climb within 1/4 mile of the power house. The voltage is 500 to 550. We have been operating single-ended cars for the last seven years. Lately we have had considerable trouble from sparking of the commutators and arcing over to the brush holder, which is at the left when one is facing the commutator. This has happened so often that it is almost impossible to keep a car on this run. We have tried several remedies without avail.

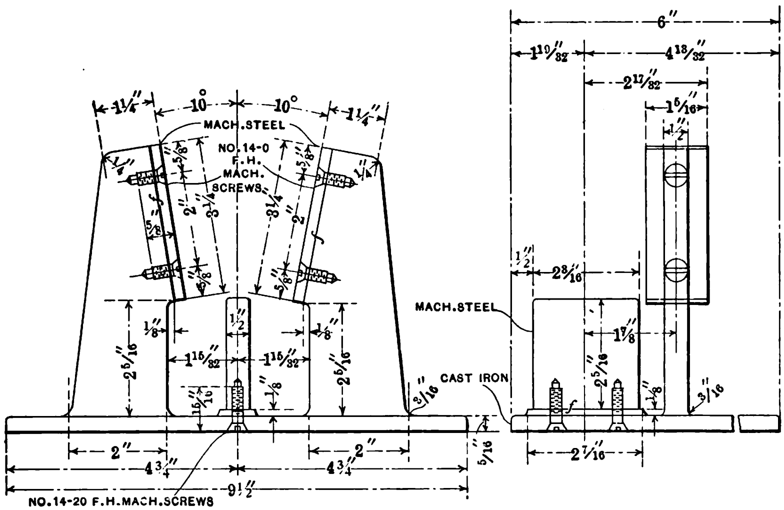
Answer.—Your trouble may be due to some defect in the line or track as well as in the car equipment itself. Connect a voltmeter from trolley to ground on one of your cars and run the car over the line, noting carefully any jumps in voltage that might be caused by broken or cut bonds. If your lines have been extended without feeders it may be that the voltage is low at the end of the lines. The increased current which is taken by the motors while operating at the reduced voltage causes overheating, and this results in flashing when sections of higher voltage are reached.

Are the commutators or brush holders of your motors worn to such an extent that you have found it necessary to shim the brush holders? If so, your brush holders may not be properly located with respect to the field coils, or they may not be spaced the proper distance apart. Brush holder shunts should be properly installed and care taken not to allow motors to operate without shunts. Are the commutators of your motors tight or do they show signs of high mica? Do you slot your commutators and are you sure you are using brushes with proper conductivity to meet your service requirements? Many roads have eliminated flashing on their motors almost entirely by slotting the commutators, using a high-grade carbon brush and making certain that the brush tension is uniform and properly adjusted to meet their operating conditions.

Correspondent's Reply.—We have tried the remedy of slotting the commutator for brush sparking, as suggested, and found that the trouble continued, but not nearly to the same extent as before. The carhouse foreman then moved the brush holder one bar against the rotation in some cases, in others as much as three bars, and the trouble has been entirely overcome. In fact, one car with a slotted commutator and the brush holder moved against the rotation has run about 7000 miles, the wear on the commutator cannot be felt, and the soft brushes we are using have worn down about 1/32 in.

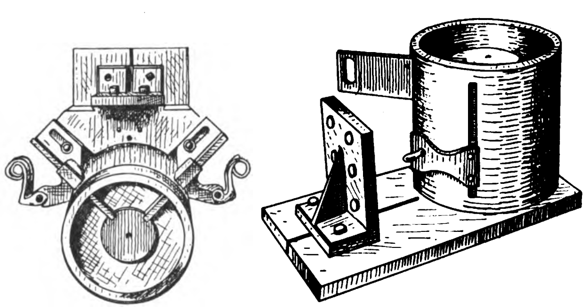
Brush-holder Jigs at Providence.—In Providence all brush-holder yokes are made to jigs, the latter being also used to realign brush holders which have become distorted in service. The jigs include a casting to represent the brush. The block used for testing the alignment of GE-800 brush holders is shown in an accompanying drawing. Only well-seasoned wood is used in brush-holder yokes in order to avoid troubles from shrinkage. Brush-holder yokes are shellacked instead of being paraffined.

Brush-holder Jigs and Armature Clearance Gages at Toronto.—The two lower drawings on this page illustrate the application of a



Block for testing alignment of GE-800 brush holders, Providence.

brush-holder jig developed at Toronto. This jig avoids all necessity for counting the commutator bars to secure the correct mechanical and electrical assembly of the brush-holder parts. The brush holders when installed are set for a tension of 4 lb. per square inch on the brushes, and



Brush-holder jig used at Toronto.

if one holder should break loose the entire yoke is returned to the shop to secure the most accurate adjustment.

The same company makes its armature bearing inspections twice a week and furnishes its inspectors with four knife-like gages about 12 in. long and, respectively, 1/8 in., 3/32 in., 1/16 in. and 1/32 in. thick. The number of every motor which is found to have a pole clearance as low as 1/32 in. is placed on a list of "Danger" cars. This list is turned over to the day foreman, who orders in for new bearings all cars thus listed after he is through with the disabled cars of the day.

Brush-holder Troubles (By W. C. Kalb).—Some of the most troublesome defects in railway motors are encountered in the brush holders, and a few of these will be illustrated by sketches. Fig. 1 illustrates the effect of a loose brush holder. With the armature in motion the brush is shifted from the neutral in the direction of rotation. It is well known that brushes on a motor should be shifted from the mechanical neutral against the direction of rotation to keep them in a position of no sparking as the load comes on, and so it is apparent that the effect of the loose holder is to make sparking more severe, as it causes a shifting of the brush in the opposite direction. Fig. 2 illustrates a similar displacement due to the fact that the guide to which the holder is clamped is not

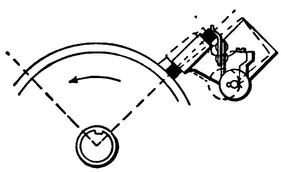


Fig. 1.—Displacement of brush holder due to loose holder.

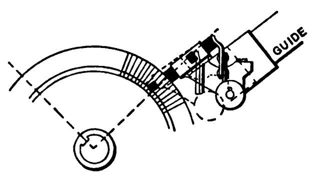


Fig. 2.—Effect when holder is not radial.

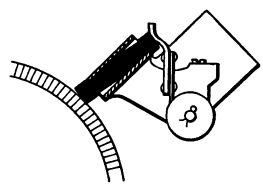


Fig. 3.—Effect of large holder or thin brush in double-end operation.

radial. The solid lines show the position with a full-sized commutator, where it is assumed that the brush bears at the neutral point. The dotted lines show the displacement when the holder has been moved down the guides to accommodate a commutator of smaller diameter. When the brush holder is worn, too large or too thin a brush will lead to serious trouble. There will then be a displacement of the brush from the neutral position, as in the case of a loose holder, resulting in increased sparking; but, in addition, serious wear and breakage of the brush arise, especially where the car is operated in both directions. This is illustrated in Fig. 3. The minimum amount of play a brush can have and not stick in the holder depends on the maintenance. Under good conditions 0.005 in. is sufficient, and it may even be less when the brush and holder are kept perfectly clean. About 1/64 in. is the maximum. Thin brushes decrease the area of brush contact surface and increase the heating of the motor.

A copper coating does no good on railway motor brushes, and often does harm, for it soon wears off and makes the brush loose in the holder. It is also liable to peel, especially with graphite brushes, and wedge the brush in the holder. The copper coating extends to 1/4 in. of the bearing surface of the brush, and when the brush is worn down so that the copper touches the commutator the sparking will melt it into globular form. These globules on the side of the brush will prevent it being removed from the holder. Copper coating should be specified for railway motor brushes only when clamp pigtails are used.

Fig. 4 illustrates another faulty practice that is frequently encountered. It is the use of a brush longer than standard or a spring of improper shape, and results in the application of the pressure at the corner of the brush instead of directly on the top. The brush wears as illustrated, and the shoulder so formed holds the brush from making firm contact with the commutator. Dirty commutator, sparking and flashes are the result.

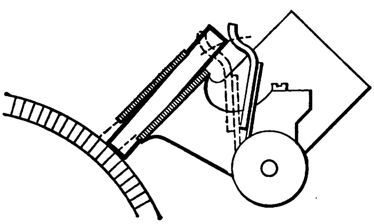


Fig. 4.—Effect of brush longer than standard or with spring too short.

The path of the hammer of a brush holder is spiral and not circular, and it is designed so that the pressure will be exerted on the center of the brush throughout its range of wear. For this reason the pressure is not thrown on the edge of the brush as it is worn short. The proper length of brush to be used is purely a matter of design. The brush holders should be kept from 1/4 in. to 3/8 in. away from the surface of the commutator, otherwise extra play will result and the chances for breakage will be considerably increased. No definite rule can be given for the number of commutator bars a brush should cover, since this is purely a matter of design. In most cases it is between two and three.

The tension of brush-holder springs should receive careful attention. If too light, brushes will chatter under the ordinary jars of service and will not be able to keep the commutator surface polished. If too heavy, excessive wear of both commutator and brushes will result and the friction loss will be high. For every road the best value should be determined by experiment, and this value maintained. No general value can be given, as it is dependent to a considerable extent on operating conditions; 4 lb. to 7 lb. per square inch will cover the ordinary range of service. Brush pressure may be measured by means of a small spring balance such as can be obtained at any sporting goods store.

Some Brush-holder Experiences (By H. Schlegel).—The present article undertakes to give an idea of what may be expected and realized where brush holders are neglected or are maintained by incompetent labor unguided by the necessary jigs and gages.

It can be stated that a number of supposedly similar factory holders subjected to gage tests showed slight differences, but in no case observed was the error sufficient to justify condemning the holder. New factory holders will maintain the correct set for months, because they are made of well-seasoned, paraffined wood and the machines for making them are correctly set for turning out a great number. This cannot be generally said of home-made holders.

With brushes set properly, the brush tension can be made light, thereby conducing to the long life of the commutators as well as high car mileage for the brushes. On a road equipped entirely with factory output, troubles usually begin with flashovers on the road, or rough handling in the shop precipitates the necessity for renewing or repairing affected parts. Independent holders of the Westinghouse type require, *per se,* no gage nor jig further than a square to see that the holder is not bent or otherwise distorted and a plug to try the brush-way for smoothness, trueness and size. The angular frame grooved seat against which the holder is drawn by the holder stud is supposed to insure radiality of the holder, assuming that the holder is true, and repair men are strongly impressed with the desirable feature of adjustment. Unfortunately this impression as generally received must be qualified, because drawing the holder down to its seat in the customary careless manner by no means insures proper adjustment and radiality of the brushes: this is on account of the roundness and obtuseness of the engaging angles on the holder and babbitted holder seat. Assuming the holder seat and insulating washer to be correct and free from burrs, bumps, swells and foreign matter that would throw the holder out of line, if while tightening the stud the holder be lightly shaken from side to side, it will draw down into its true seat, and inspection of a new brush against which the commutator has been rotated will indicate the line of bearing contact to be down the center of the brush. On holders of the independent type a line down the bearing surface of a new brush or perfectly square wear of the old brushes is an indication of correct position of the brushes on the commutator. On holders of the yoke type this is not so because brushes are often square with each other, have the correct spacing and make full contact with the commutator, but both are too far over in one direction or the other, thereby causing the brushes to spark for one direction of motion of the car but not for the other. If the line of contact is in the center of bearing of the brushes, the adjustment may be accepted as correct.

If no special precaution is taken to have the apexes of the holder, insulator and babbitted seat coincide, on drawing home the brush-holder stud these parts will bind slightly on the diagonal and thereby throw the brushes as much as one and one-half bars out of the way, with sparking as a result. If the babbitted seat is not true or the insulation washer is not of uniform thickness, the brush adjustment will be in error. The only way to get the seats absolutely true is to use a babbitting jig, preferably obtained from the factory; after securing a correct jig it should not be thrown around and allowed to lie where it will be run into by a truck or barrow, or where a motor will be let down onto it from a hoist—a jig that is wrong is worse than no jig at all because it is misleading. Where a holder is so distorted as to throw the brushes across the commutator (Fig. 1) out of parallel with the commutator bars, or one end of the holder is further from the commutator than the other (Fig. 2), the brushes are caused to wear more on one end than on the other and may confine the current to an area unable to carry it without sparking—the first impulse of the average repair man is to straighten the holder.

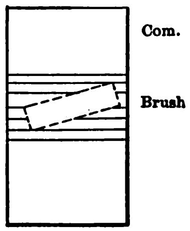


Fig. 1.

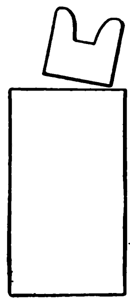


Fig. 2.

Before changing a holder in any way, proper steps should be taken to ascertain if the faulty setting of the brushes is or is not due to irregularity in the holder itself. Under no circumstances should a holder be altered until it is proved to be wrong. A simple way to localize the fault is to substitute a factory holder that is known to be right and that is reserved just for checking the condition of suspected holders. If the standard holder sets right, then the fault is with the suspected holder that is replaced; but if the standard gives the same evidence of error, the irregularity must be elsewhere—either in the babbitted brushing or insulating washer. In either case correction there means that distortion of the holder by bending to straighten (?) it has been wisely avoided. In testing the adjustment of any holder, care must be taken to see that the stud bolt is drawn sufficiently tight to draw all parts firmly to their seats, otherwise an apparent error in adjustment will be due to the operator and not to the holder. At times a holder will be found actually to need straightening—probably foolishly bent on a former occasion when the fault was really elsewhere.

Another popular way of abusing the Westinghouse type of independent holder is to use a hammer and chisel for forcing the holder up or down on the insulating head when it is desired to move the holder in or out in accordance with commutator wear. This treatment burrs or swells the brass holder into the insulator, thereby so much increasing the interference between them that in future adjustments the holder must be removed from the motor—a feat that cannot always be accomplished without opening the motor frame. Such holders will go unadjusted out in the operating house, where the importance of a brush adjustment is not generally acknowledged and where the general topography of the lower part of many cars may be such that it is impossible to adjust holders unless that can be done easily. For purposes of adjustment where the holder strongly resists being moved in or out on the insulating head a pair of tongs similar to those used by a blacksmith to hold 4-in. to 5-in.

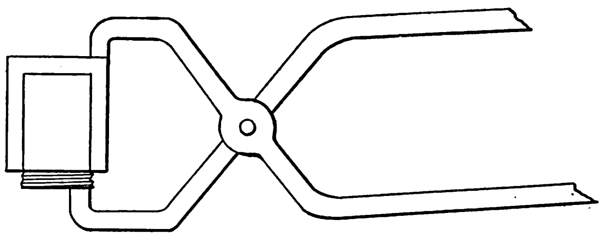


Fig. 3.

stock can be used to advantage. The handles must be about 5 ft. long and the jaws shaped to suit the space conditions around the holder. To use this tool (Fig. 3) one jaw of the tongs is rested on the insulator and the other on the brass part of the holder, pressure being then exerted by resting one handle against the shoulder and pulling on the other; it takes a very obstreperous holder to withstand this pressure.

On all yoke types of holder the most prolific source of error is in the yoke itself, for if the yoke is wrong in the first place it will stay wrong and become worse, because where the proper precautions are not taken to prevent the yoke from shrinking as a result of the heat to which it is exposed, it will shrink and put the brushes in error. The guide mountings are also qualified to give much trouble. In some shops the guides on which the holders slide are bought finished and then mounted on the yoke; in other shops the rough castings are bought, then mounted on the yoke and afterward milled in position. Either method can be carried to successful results if proper care is taken, but it is very hard to maintain necessary care where the demand for holders is insufficient to warrant permanent setting up of the machines engaged in their making. It is difficult to keep the output from gradually drifting into error, assuming that all conditions are correct in the first place. As stated before, unless a great deal of care is taken to get thoroughly seasoned wood and so to treat it that it will not afterward absorb water, the resulting holders will warp, and almost imperceptible warpage in the holder itself will introduce appreciable error in the set of the brushes several inches away (Fig. 4). The same, in effect, is true of the holders and the guides on which they slide. If the guides are not adjusted to a true right angle with the apex at the center of the armature, then the brush-count will increase or decrease with commutator wear, according as the apex is above or below the armature center. An error in the angle that the holders make with each other due to irregularity in the position of the guides is multiplied at the points where the brushes bear on the commutator. Where the finished guides are mounted on the yoke, there is liable to be error in the mounting; where the rough guides are mounted in the yoke and then machined, there can easily be error in the milling, either as a result of the machine being set up wrong or of the yoke being flimsily supported so that the cut runs off at the end, thereby producing a holder with curved guides (Fig. 5). If the guides are finished too narrow for the guideways on the holder, there results play which will introduce error in the set; if the guides are finished too wide for the guideways in the holder, it will be impossible either to install the

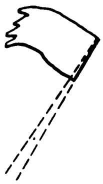


Fig. 4.

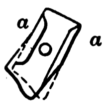


Fig. 5.

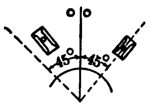


Fig. 6.

holder on the guide or it will be installed against an interference that not only will give the brushes the wrong set but will so distort the guideways that they will have no precision in future. If the yoke goes out to a depot where everything that is done is done in a hurry and with no room nor light for working, the probabilities are that the holder will earn its right to the scrap pile.

Where the guide is too wide for the guide-way, the tendency to file again asserts itself; in a depot this may be the only practicable way to get a much-needed car on the road; but in the shop no filing should be done until proper gaging shows which part is in error. It must be borna in mind that not only must the guides make a right angle with each other, but their axes must intersect at the center of the armature; furthermore the axes must make equal angles with a line drawn to intersect the armature center and the center of the line of support of the holder (Fig. 6), otherwise the brushes will spark in one direction of movement of the car but not in the other.

Assuming that the guides test to a true angle and that they are located symmetrically with regard to the center line but that on fitting them with holders, putting them in a motor and counting the set the brushes prove to be too far apart, the only thing to do is to reject the holder for correction. If, however, the error is such as to bring the brushes too close together, their distance apart can be increased to almost any reasonable degree (and without introduction of other errors) by inserting between the holder supporting bracket and the machined seat that it engages on the upper shell a fiber liner that is effective in moving the holder bodily downward. Before tightening the holder yoke, the holders must be loosened, because lowering the yoke moves them closer to the commutator, and if the yoke is tightened with the holders bearing on the commutator, the results will be misleading. The practicability of so correcting a faulty brush set is convenient in depot practice, but is not to be used in shop work. A yoke issuing from the shop should be *per se* correct in every respect. Such a feature suggests the possibility of error coming in as a result of the brush-holder supporting bracket being planed off too much or too little (Fig. 7), the effect being to move

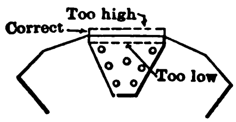


Fig. 7.

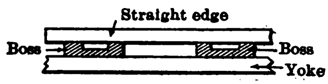


Fig. 8.

bodily the yoke and holders nearer to the center of the armature or further from it, thereby introducing variations in the brush set. Unless great care is taken to mill the seat of the supporting bracket correctly the result will be to introduce error in a yoke that is otherwise all right. To illustrate the importance of this feature, it may be stated as a fact that a yoke and holders that give the correct brush adjustment when the armature bearings are new will bring the brushes too close when the bearings are worn, because such wear lowers the commutator bodily, thereby causing the brush-holder axes to intersect at a point above the center of the armature. The effect of bearing wear is most noticeable on motors the armature bearings of which are babbitted above the center to increase the life of the bearings. The change of brush adjustment may amount to as much as three-quarters of a bar. Brushes that are three-quarters of a bar too close together will give more trouble than those three-quarters of a bar too far apart; in fact, in one case within the writer's knowledge the behavior of a lot of GE-1000 motors, that were being abused, was much improved by setting the brushes more than a half-bar too far apart.

In counting off the set of brushes it is important that the brushes rest parallel to the commutator bars, otherwise an error in count is liable to obtain. The usual cause of error in parallelism is that the machined bosses (*a*, *a*, Fig. 5) against which the brush-holder guideways bear are not in the same plane. On old yokes this may be due to the yoke having warped into a curved shape: the only treatment for such a yoke is to discard it. On new yokes the guides may be milled unevenly or they may set on the yoke unevenly; in any of these cases the effect is to have the brushes set crossways on the commutator bars, with the result that the brush, instead of short-circuiting two or three bars, will short-circuit from three to five bars and produce sparking in both directions. The test for evenness of the bosses on which the guideways rest is to lay a straight edge across them; the straight edge should touch every boss (Fig. 8). In milling the bosses in position, care must be taken that the yoke sets level so that the same amount may be cut from the bosses on both sides of the holder. In trying a complete yoke in a motor to count off the brush set clean the frame seat against which the supporting bracket bears, because dirt or the remains of a liner formerly used there will cause error in the set.

Tests of a large number of carbon brushes show that the variations in their thickness are considerable, especially in the case of brushes from different makers. It would be well, therefore, to have brush-ways and brushes of uniform thickness, and to this end gages should be used; if a brush is wrong, change it or use one the thickness of which is known to be right. If the brush-way is too narrow, inspection may reveal some local imperfection which may possibly be readily corrected. If the brush-way is too wide, the holder should be discarded, because where there is too much play between the brush and way the bearing surface of the brush wears to two surfaces at angles to each other—one surface for each direction of rotation, and not only changing the brush set but reducing the bearing contact to a degree that may cause the brush to heat. Brushes also may be thicker on one end than on the other, so that the brush may show some clearance when first installed, but as it gets shorter from wear and the thick end enters the holder there ensues a binding action certain to result eventually in a flashover. Excessive clearance between the brush and brush-way is especially liable to cause trouble where no attention is given to adjusting the distance or clearance between the holder and the commutator. This distance should be the least that will allow the holder to clear everything. On many neglected armatures in which wear in the thrust collars permits excessive end play, it is not practicable to run the brushes as near as they should because when the armature pulls over to the commutator end the holder will strike the commutator ear. Such a condition is generally indicated by a brush hanging over the end of the commutator or resting too far from it, and should be tested by forcing the armature as far as possible in both directions to determine the end play; in any case an armature with excessive end play should not be passed. A satisfactory clearance between the holder and commutator is 1/8 in. Satisfactory end play is 1/32 in. when the armature is hot and the motor cold. It is not uncommon to see the holders in a motor just from the factory almost 1/2 in. from the commutator.

Another important feature much neglected is brush tension, that is, the tension of the springs that press the brushes down on the commutator. We are not in a position to recommend just what the brush tension per square inch of bearing surface should be, but feel safe in saying that on a good rail and with brush adjustment in all respects correct it need not exceed 5 lb. per square inch. On rough rail abetted by absence of regard for brush inspection, the brush tension must be strong, otherwise brushes will jounce at joints and cause flashovers. When one knows that motors of the same capacity shipped to the same service by different companies vary as much as 50 per cent. in the tension, it is hardly doubtful but that difference of opinion to be respected exists in regard to what the tension should be. All tension in excess of what is needed is expended in causing useless wear of commutator and brushes; brush tension, then, is evidently a condition worth considering. While the absolute tension per square inch under given conditions may be an open question, there is no excuse for having the tension of one brush on a motor 2 lb. and that on the other 6 lb. per square inch. There might be some difference in the tension to be recommended on holders of different types, because some are more effective than others; but this difference is not nearly as great, so far as the writer has been able to observe, as the differences that exist on the different brushes of the same motors where this feature has been neglected for years. As an instance, take the cases of springs of the kind used on the old No. 3 and the later No. 68 Westinghouse motors; these give satisfaction and have done so for a long time or they would have been discarded. Where the spring is properly assembled and installed there is but slight variation in pressure between the two positions occupied by the finger when the brush is new and when it has been allowed to wear a safe amount; but if the contact finger is so made or so fastened to the spring that when winding up the spring to get the proper tension the hump in the finger is caused to bear against the side of the brush instead of the top the force component tending to press the brush to the commutator is small and a much greater total tension must be used. In getting this greater tension the tip is liable to be drawn over so far as to leave no finger room on the end for raising the finger. On brush holders of the General Electric type, using the spiral spring, once the proper tension (hence the proper size and composition of wire) has been selected, steps should be taken to maintain this selection, otherwise springs of various kinds, sizes and characteristics will creep into repair practice and cause changes in brush tension.

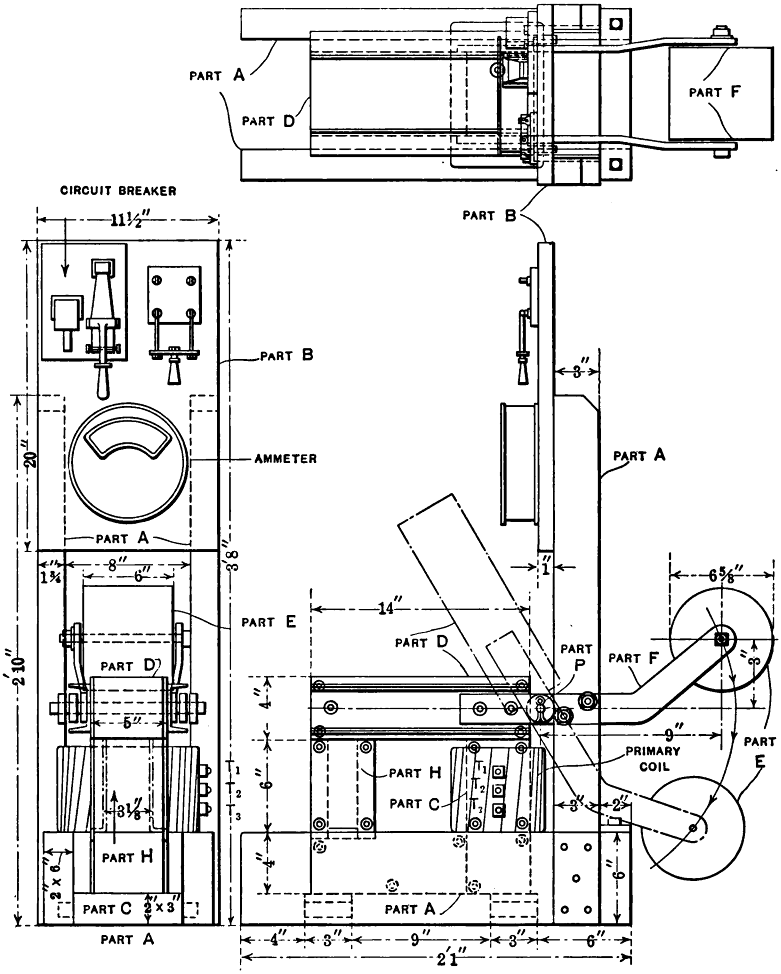
Finally, a word about the number of brushes to be used in each holder. There are good motors with two brushes per holder and there are seemingly just as good motors with one brush per holder. The writer may be prejudiced in favor of two brushes because he once saw a lot of hill-climbing motors cured of bucking by substituting two brushes for one; but aside from prepossession in their favor, common sense seems to be on the side of using two brushes per holder. Two brushes certainly better tend to equalize general faults of adjustment and to secure a fairly good brush contact under conditions not to be obtained with a single brush. When a single brush is stuck in one place it usually might just as well be stuck all over. With a single brush the effect of uneven brush tension on its two sides increases with age; with double brushes it remains the same. The fact that the manufacturing companies have practically adopted the double brush would leave little doubt as to which is considered the best; yet the operating companies in possession of motors provided with single brushes do not seem to be in any particular hurry to change. From the depot man's point of view consider a single wide brush with two contact fingers that do not stay raised; the brush man has to hold up both of them in order to withdraw or insert a brush. With the tension twice what it should be, the motor hot and the brush man in a position representing a compromise between rope walking and piano moving, evidence indicates that the pleasure is not all his and that those brushes will not be renewed any oftener than they need be; generally he will use his gas tongs to hold the fingers up and in doing so he runs the chances of getting a burn or shock. We consider it an advantage to have brush-holder fingers that have no neutral position because it is impracticable to leave them up. Where the brush is split it is easy to hold up the fingers one at a time. Where a single brush is wide and has two fingers that have no neutral position renewals will be made as often as they should be.

Theoretically, on a four-pole machine the correct spacing of the brushes is one-quarter of the circumference of the commutator. Calling a bar and its mica body a unit, a circumferential count from the center of one brush to the center of the next should include one-quarter of the total number of units. On railway motors it would be impracticable to count from center to center, so the count is made from the inside edge of one brush to the inside edge of the next one; this is seen to be one-quarter of the total number of units less the number of units covered by two half brushes. Assuming the brush holder to be strictly correct, as the commutator wears, the count between brush centers remains the same, but the count between inside edges becomes slightly less because the bars get thinner and two half brushes cover more units to be subtracted. This difference is insufficient to make any practical difference except when the data are being collected for making a gage or jig.

Field Testing at Brooklyn.—In the field-testing apparatus of the Brooklyn Rapid Transit System illustrated the principle of the transformer is used. The field under test acts as a secondary and a coil made up of eighty-one turns of No. 5 D. C. C. wire acts as a primary. The primary coil receives current from a small 110-volt, 35-cycle generator, which is driven directly from the main shaft. This coil also has a 40-amp. circuit-breaker, an ammeter and a 90-amp. double-pole, single-throw switch in series. First the reading of the ammeter is noted when the switches are closed and without a field coil in position for testing, this reading corresponding to the primary current of the transformer when the secondary is open circuited; or this will be the reading of the ammeter when the field coil under test is in good condition and without short circuits. A reading higher than this normal reading indicates that the field coil has a short circuit, the reading varying in accordance with the number of turns thus short circuited. If the current is maintained for a while, the point of short circuit will be indicated by the additional heating of that portion of the coil. In testing for open circuits one terminal of the coil is grounded and a light circuit is put on the other terminal. The burning of the lamps, of course, will show the absence of open circuits.

The construction of the field-testing outfit consists of the parts shown in an accompanying drawing. The framework part, *A*, is made of wood. Part *B* is a slate panel, 20 in.×11 1/2 in.×1 in., on which the circuit-breaker, ammeter and switch are mounted. Parts *C*, *H* and *D*, which comprise the magnetic circuit, are made up of several thicknesses of 1/32-in. wrought iron dipped in shellac. After the shellac is dried, the laminations are placed between the two 1/4-in. side pieces and riveted together. The primary coil is made up of eighty-one turns of No. 5 B. & S. D. C. C. wire with twenty-seven turns between *T*-1 and *T*-2 and eighty-one turns between *T*-1 and *T*-3. Part *E* is a cast-iron counterweight 6 5/8 in. in diameter and 6 in. wide which assists in raising part *D* and also in keeping it in the upper position while a field coil is being placed in position for testing or while one is being removed. The arms, part *F*, are made of 1/2-in.×2-in. flat iron, are bolted to part *D*, have the counterweight attached at the other end and are free to turn on a pin. Part *D* and counterweight *E* thus revolve on the same pin, which is supported by two brackets, one on each of the upright members of the wooden frame.

To test a field coil, *D* is raised and the field coil is slipped over *H*. *D* is then lowered, in which position it rests on *H* and *C*. After the field coil is in position and *D* has been lowered, the circuit-breaker and switch

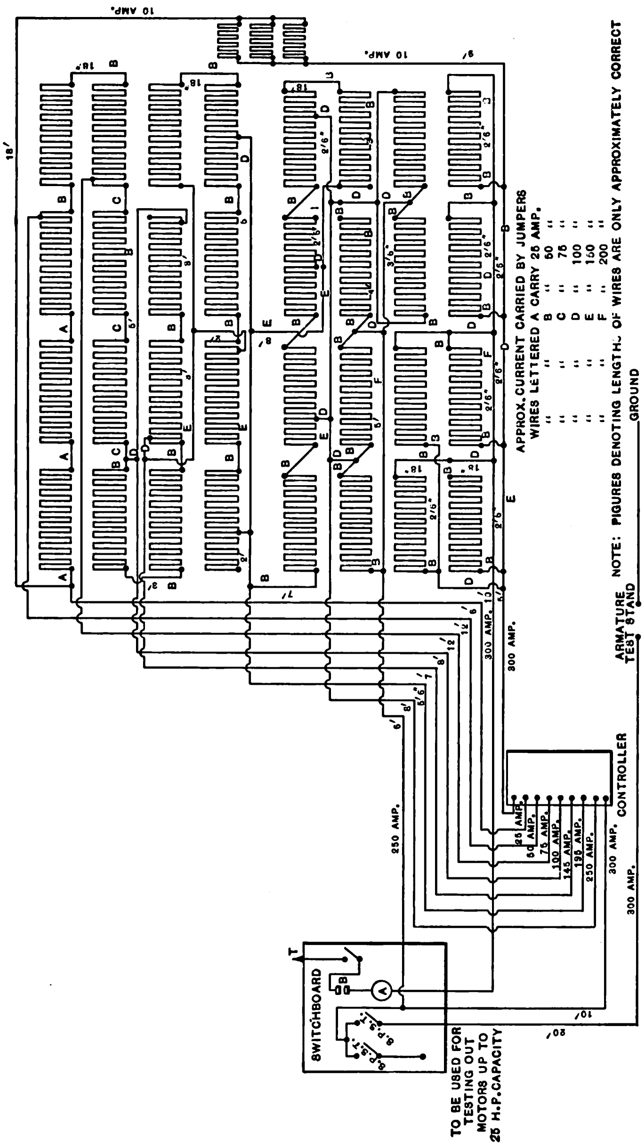


Field-testing outfit, Brooklyn.

are closed, thus sending alternating current through the primary coil. The terminals of the field coil under test should be entirely free and not connected together.

A transformer box is used for testing windings for any potential up to 6000 volts. The 500-volt d.c. lighting circuit is used for testing individual coils before they are assembled.

Armature Testing at Brooklyn.—A very important factor in the reduction of maintenance costs on the Brooklyn Rapid Transit System has been the installation of equipments for testing fields, armatures, heaters,



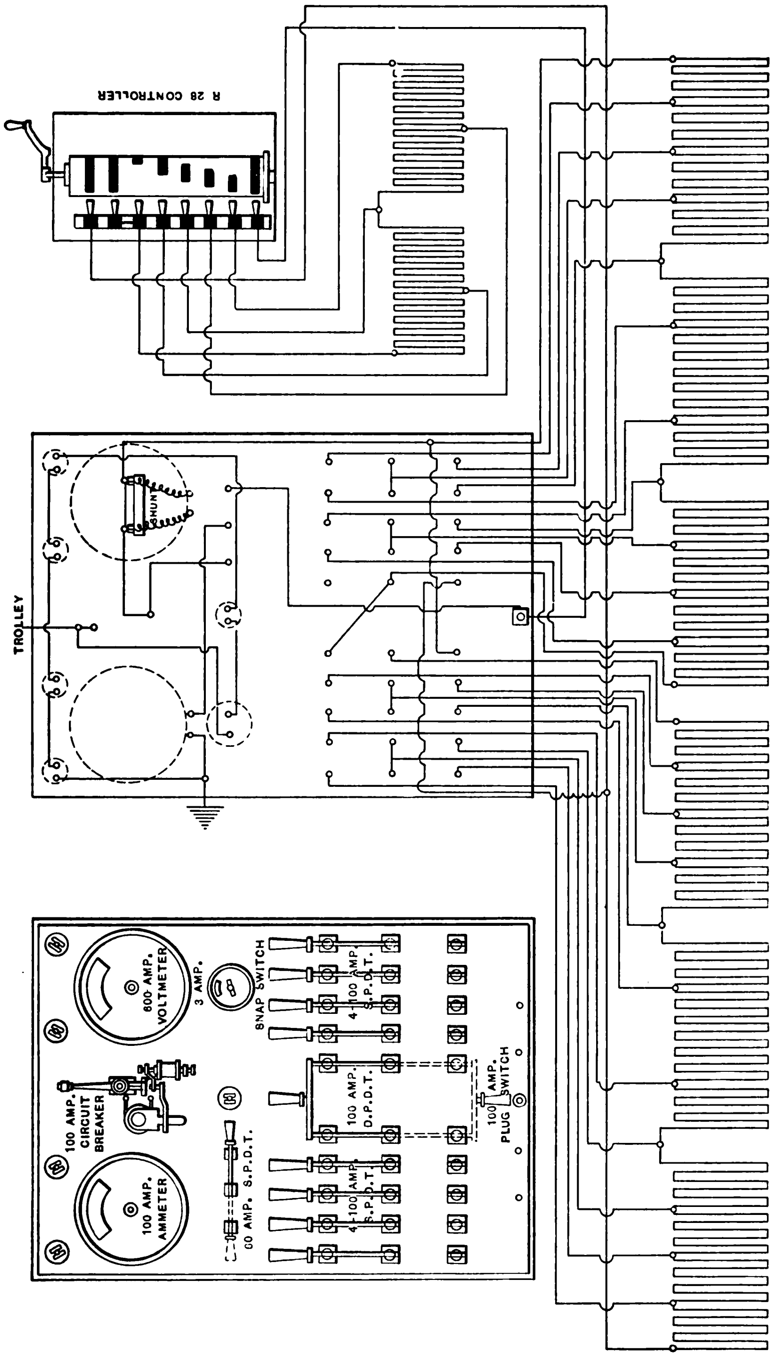
Switchboard and resistance wiring diagram for armature-testing outfit, Brooklyn.

jumper connections, circuit-breakers, etc. The most elaborate installation of this kind is the armature outfit for testing poor soldering, commutator short circuits, or short circuits in the armature itself. The equipment comprises a rheostatic controller, a set of car resistances which give any desired amount of current from 8 amp. to 300 amp. in order to include the currents used by the motors in service, an ammeter to measure the current going through the armature coils and a millivoltmeter to note the drop between commutator bars. By passing an operating current through the armature it is possible to discover such defects as would otherwise develop after the armature had been placed in service on the car, namely, melting of poorly soldered connections and the burning off of abraded wires. By permitting the armature to receive exactly the same current as if it was installed between the fields of its motor, the practical benefits of an actual test on the car are obtained without the inconvenience of removing and replacing an armature which might prove defective.

The connections of the armature-testing outfit are indicated in the accompanying wiring diagram. The adjustment of the brush holders for any size commutator is obtained by means of two slots in the board through which the terminals are connected to the brush holders. A shelf above the armature stand is used for trying out and adjusting circuit-breakers. Circuit-breakers used on four-motor equipments are set to blow at 325 amp., and those on two-motor equipments are set at 275 amp. Armatures of compressor motors are given a running test by installing them in a compressor located near the field-testing outfit. As this compressor is furnished with a split frame, the armatures are taken in and out very readily.

Armature Testing at Cincinnati.—At the shops of the Cincinnati Traction Company, the armature winders make their own tests before placing a completed armature in the shop stock, and the assistant foreman makes the final test. All new work is tested at 2500 volts and all repair work at 1500 volts. All new armature work is paid for on a piece basis and the company requires that it must stand up in regular service ninety days or the workman who did the winding will be required to repair it on his own time. All armatures, after being rewound, are dipped and rolled in a shallow tank filled with black plastic and they are then placed in the oven and baked until the plastic has thoroughly dried.

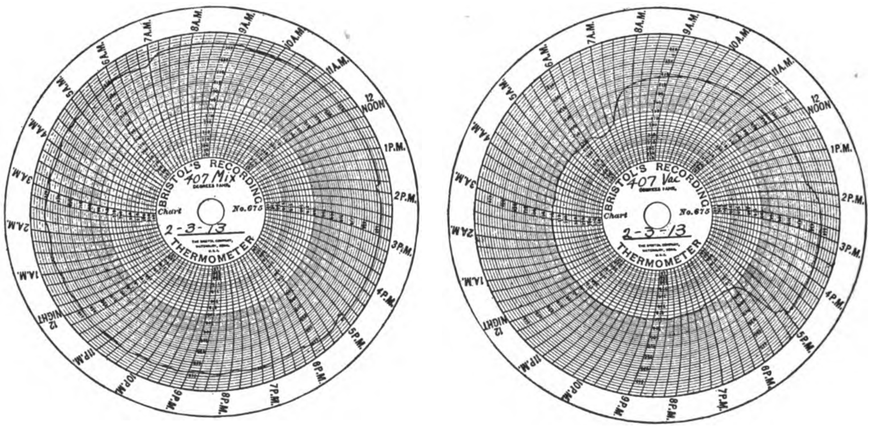
Motor Testing at the Indianapolis Railway Shops.—Every car motor that is repaired in the Indianapolis shops is given a running test on the shop floor before it is put under a car. A table of constants for the current and voltage readings for each type of motor has been prepared, so that when a motor is being given a test and the current and voltage values are noted it then is possible to determine fully whether or not the motor is running freely. If the bearings should not have been fitted properly the extra demand for current will indicate the fact. By the careful use of testing methods many causes for motor heating are learned



Wiring diagram for motor testing board, Indianapolis.

in the shop where they can be easily corrected, and unnecessary pull-ins be prevented.

The testing board stands at one corner of the truck repair shop. An independent feed line direct from the power house furnishes current to this board. By means of this special connection the voltage regulation obtained at the testing board is equal to that of the power station busbars and is not affected by the shifting of cars in the shop yards, as it would be if the testing board were fed from the trolley wire. The board is equipped with a 100-amp. ammeter and a 600-volt voltmeter and is protected by a 100-amp. circuit-breaker. The lower part of the board carries eight single-pole, double-throw, 100-amp. knife switches and a double-pole double-throw switch, by means of which the various resistance grid connections are made to obtain a wide range of resistance values for comparative purposes. With these connections a range of resistance from 8.42 to 26.48 ohms in steps of 0.25 ohm and from 2.12 to 7.38 ohms



Temperature records of compound and vacuum tanks, Brooklyn Impregnation Plant.

in steps of 0.052 ohm may be obtained with facility. The controller is R-28. Testing current is distributed from the board to four parts of the shops over cables in iron conduit. These cables end just below the test board and each has a feed connection plug. As there is only one live socket to which these plugs can be connected, it is impossible for more than one distributing line to be alive at one time, thus avoiding accidents.

Impregnation of Field Coils at Brooklyn.—For two or three years previous to 1910 the Brooklyn Rapid Transit System had in service several thousand field coils that were impregnated by the manufacturers of the motors. The impregnated coils proved so satisfactory that the company decided to install a plant of its own at the Fifty-second Street shops which are exclusively for electrical work. This equipment consists of one vacuum and one pressure tank. The tanks of this design are heated by a steam jacket instead of steam coils, allowing them to be cleaned with greater ease. No trouble had been experienced from leakage of the steam jackets. This equipment has been in operation from June 4, 1910, and from that date to Dec. 31, 1912, 12,817 field coils, or approximately 73.33 per cent. of a total of 17,478 coils, had been impregnated. Experience has convinced the company that impregnation has easily paid for itself in lengthening the life of the coils and thus minimized their rewinding.

An important auxiliary to each tank is a recording thermometer. The dial of each thermometer bears an identification number which is also stamped on the tin tags which are attached to each field coil of the group impregnated at any given time. In this way a record of the temperature conditions which exist in each tank at the time the work is done is obtained so that a possible clue is afforded to determine the cause for any trouble which an impregnating coil may develop later in service. The reproductions on page 138 of a pair of these records refer to the impregnation of twenty-two Westinghouse No. 81 coils which were tagged as part of group 407. The records show the changes in temperature from the time the coils were placed in the tank, 5 p. m. Feb. 3, 1913, to the time they were taken out, 5 p. m. the next day.

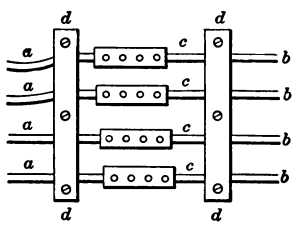
Impregnation Practice at Anderson, Ind.—In connection with the standard type of impregnating apparatus used at its Anderson shops, the Indiana Union Traction Company has arranged a gasoline coil burner around the base of the tank. The gasoline supply is received from a sunken reservoir outside the shop building and is distributed under pressure for this use and for heating tires. The impregnating plant is directly under the main shop crane.

The following particulars regarding the method of operating this vacuum drying and impregnating plant may be of interest. One of the main points which is kept in view is that of maintaining a uniform temperature in both of the tanks while the compound is in a liquid state. The temperature is maintained between 310 and 320 deg. Fahr. When starting up with a supply of cold compound about 15 hours' time is required at the above temperatures to liquefy the compound.

In checking the temperature of the tank containing the compound a section of iron pipe with one end plugged is used to permit the insertion of the thermometer well below the surface of the insulating material. The temperature of the vacuum chamber is found by inserting the thermometer in an oil pipe provided in the cover. It is stated that the temperature of the vacuum chamber as thus found is about 40 deg. below that on the inside of the tank when the cover is in place, so an adjustment of 40 deg. is made. In connection with the use of gasoline for heating, it is found necessary to watch the temperatures of the tanks carefully when the gasoline supply tank outside the building has been filled. For a period of about an hour after this has been done the fresh gasoline seems to make a much hotter fire than at other times.

Coils which are wound with double cotton-covered wire are insulated as follows: The sets of coils are first put in the vacuum chamber and allowed to be heated to a temperature of 320 deg. in about four hours' time; then the vacuum pump is started and the coils kept under vacuum for three hours. Next the vacuum line is closed and the large gate valve between the vacuum tank and the supply tank is opened, allowing the hot compound to run into the vacuum chamber and submerge the coils about 6 in. Next the gate valve is closed and an air pressure of 60 lb. is turned on for three hours. After this treatment the air pressure is reduced to 15 lb., the gate valve opened and the compound forced back into the liquid supply tank. The coils are then allowed to drain for about half an hour, when they are taken out and the layer of cheap cotton cloth which first had been put on as stripping is removed. This cloth takes away with it the excess compound and leaves the coils with a smooth surface on which the finishing insulation is placed.

Motor Lead Connections.—All electric railways have trouble with loose or grounded motor leads followed by fire. The following simple precautions will help to avoid such trouble: On double-truck cars bring the cable taps opposite the motor area subjected to the last sweep on curves and bring the motor terminals out through this area even if it is necessary to redrill the motor shell. Use only the best flexible wire in the leads. See that the motor lead wire fits the motor lead bushing and that the bushing fits the hole in the shell.

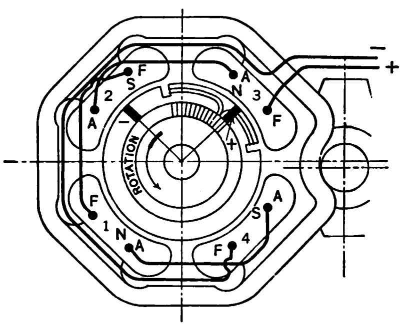


Motor lead connections.

As grease rots the bushing do not use it as a lubricant in pulling the lead through the bushing, but employ soapstone or clay.

Where special terminals are used, both the cable taps and motor leads must be sweated into them and the job tested by a strong pull. If ordinary sleeve connectors are used, they are sweated to the cable taps and the carefully prepared ends of the motor leads brought into the other ends of the connectors. To prepare the ends skin off 1/2 in. more insulation than is apparently necessary, so that there will be some wire to cut off, and leave the remainder full size clear to the end. Maintain the original "lay" of the wires, dip in hot solder, cool and trim with a file, then cut off to the proper length to insure that both connector screws shall have full bearing on the wire. In connecting, screw home the inner screw first and be sure that the inner screw alone can hold the wire against a strong pull; then tighten the outer connecting screw. To get rid absolutely of all working pull between the sleeve connector and any of the conductors engaging it, it has been found good practice to put a four-hole wooden cleat on both sides of the connector, as in the figure where *a, a, a, a,* are the cable taps; *b, b, b, b,* the motor leads; *c, c, c, c,* the connectors, and *d–d, d–d,* the wooden spreaders or cleats. The connectors can be accessibly protected by short sleeves of flexiduct or garden hose which can be pushed aside when it may be necessary to get at the screws for disconnecting.

Railway Motor Connections. *Question.*—Will you kindly explain how with an ordinary sewing needle and a positive lead from a water rheostat one can test the polarity of the fields and then that of the armature of any new motor so that the motor will rotate in the right direction upon the first application of emf? There should be some method more scientific than connecting up the field with ground wire absolutely right and taping the joints of the same but leaving the armature terminals bare for reversing the connections in case the motor does run in the wrong direction. After once connecting any new motor, applying the current and noting the direction of rotation, anyone should be able to figure out the various connections for all different local conditions. In short, it should be possible to figure out the correct connections, then connect up by all four motors, tape the twenty connectors, cleat the wires and upon starting find that all four motors run correctly.



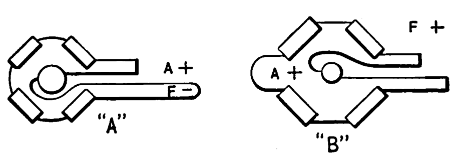
Determining the direction of rotation in railway motors.

I should also like to know why a series motor when running full speed will not generate a dynamic braking load if the free $A+$ and $F-$ leads are connected as shown in the left-hand sketch, whereas it will do so when connected as shown in the right-hand sketch, herewith, and furthermore will draw a big arc if opened before the rotation of the armature ceases.

Answer.—The using of a sewing needle is not desirable as the polarity of the needle is liable to change because of the influence of the fields. One method of determining the polarity of field magnets is by means of a compass. If a small current is passed through a field coil and a compass is held a short distance away, the south pole end of the needle will point toward the field if it is a north pole and the north pole end will point toward it if it is a south pole. When the direction of the winding about the pole is known, its polarity may be determined by the direction in which the current flows around it. One simple rule for remembering this relation is that when a person is looking at a north pole the current is flowing around that pole in a counter-clockwise direction to him, and when he looks at a south pole the current is flowing around that pole in a direction which is clockwise to him.

The following method of testing the polarity of the fields of railway motors after they are connected is employed by several large railway shops. Two bars of iron about 8 in. long are used. One end of each bar is placed in the center of two adjacent pole faces, and the other ends are held about 1 in. apart. A current of about 1 amp. is then passed through the field coils, and if the connections are properly made the iron bars will be drawn together by their attraction for each other. With one end of each iron in the center of two opposite pole faces, the other ends will be forced apart. Care should be taken to use but a small current through the fields, or the iron bars will be drawn together with such force as to be liable to injure the person holding them. If much testing is to be done it is best to provide the irons with handles about 3 ft. or 4 ft. long so that a man can hold them without danger. The accompanying illustration shows the polarities of a four-pole railway motor. The two north poles are directly opposite each other, and the two south poles are opposite each other.

When the polarity of the field magnets of a motor is known the direction that the current must pass through the armature coils to produce a given direction of rotation is easily determined. One simple rule, sometimes called the rule of the thumb, is the following: Place the palm of the left hand toward a north pole and the extended thumb pointing in the direction it is desired to have the armature rotate. Then the current through the armature coils underneath this pole must flow in the direction the fingers are pointing.



Non-effective and effective connections to make motor act as a generator.

Referring again to the illustration on page 143, the poles 3 and 1 are north poles, and to make the armature rotate in the direction indicated by the arrow—that is, counter-clockwise—the current in the armature coils under 3 and 1 must flow away from the observer. Looking at the commutator end of this armature, it is therefore necessary that the positive brush holder should be located in front of field coil 3, so that the coils to which it is connected through the commutator will have the current flowing in the proper direction.

In reply to the second question: a series motor will not generate if the field excitation and the residual magnetism are not in the same direction. When the current used to drive a motor is shut off, a small emf. is generated in the armature by the residual magnetism of the fields. This sends a small magnetizing current through the fields, and if this current produces lines of force in the same direction as the residual magnetism there will be an increase of the emf. and field current so that the motor will build up and generate. If this current does not excite the field in the same direction as the residual magnetism, the field magnetism is decreased so the motor cannot build up and generate. To use a motor for electric braking it is therefore necessary to reverse the connections from those used as a motor so that the current generated will flow through the fields in the same direction as when the machine is used as a motor.

Motor Data Sheet, Hartford.—The motor data sheet produced herewith is uniform with other instruction prints at the Hartford shops of the Connecticut Company. This table, which was checked by the motor manufacturers, not only presents the usual data in regard to capacities, weights and gearing, but also includes statistics of special value in the shop, such as the number of coils in the armature, the number of armature bars, the throw of the coils, the original and safe wearing diameters of the commutator, the number of turns in the field and the size of wire.

HARTFORD SHOPS—DATA SHEET ON TWENTY-FOUR TYPES OF RAILWAY MOTORS

Motor	H.p.	Wght. with gear and gear case	Max. diam. of axle	Clearance above rail 33-in. wheel		Sum of gear and pinion	Gear ratio			No. coils in armature	No. com. bars	Throw of coils	Orig'l com. diam.	Safe wearing diam.	No. turn in field	Size of wire	Weight of equipment	
				Motor	Gear case		Stand.	Min.	Max.								Two motors	Fours motors
GE-1,200....	38	2,900	4	......	.....	77	17.60	17.60	27.50	105	105	1–27	$8\frac{1}{2}$	$7\frac{5}{8}$	270	No. 6	7,000	14,200
GE-1,000....	35	2,200	4	$4\frac{11}{16}$	$4\frac{5}{8}$	84	17.67 19.65	17.67	22.62	93	93	1–24	$8\frac{3}{4}$	$6\frac{5}{8}$	143	No. 4	5,400	10,200
GE-800......	25	1,800	4	$5\frac{1}{16}$	$4\frac{5}{8}$	81	14.67	14.67	14.67	105	105	1–27	$9\frac{1}{8}$	$7\frac{5}{8}$	203	No. 6	4,600	8,500
GE-90.......	50	2,489	$5\frac{1}{2}$	$4\frac{3}{8}$	4	86	15.71 17.69 19.67	15.71	22.64	29	145	1–8	$9\frac{5}{8}$	......	$90\frac{1}{2}$	No. 2	6,765	13,750
GE-87.......	60	3,430	$5\frac{1}{2}$	$3\frac{1}{2}$	4	87	16.71 18.69 20.67	16.71	23.64	43	129	1–11	11	$9\frac{1}{8}$	$87\frac{1}{2}$	2 No. 4's	8,035	16,290
GE-80.......	40	2,830	$5\frac{1}{2}$	$4\frac{1}{8}$	4	86	15.71 17.69 19.67	15.71	22.64	37	111	1–10	$9\frac{5}{8}$	$7\frac{3}{4}$	$110\frac{1}{2}$	5 BWG	6,540	12,750
GE-74.......	65	3,574	6	$3\frac{1}{2}$	$4\frac{1}{8}$	89	16.73 19.70 22.67	16.73	28.61	39	117	1–10	$11\frac{1}{4}$	......	$70\frac{1}{2}$	1.531×0.053	8,318	15,736
GE-73.......	75	4,147	6	$3\frac{1}{2}$	$3\frac{5}{8}$	75	17.58 19.56 21.54	17.58	24.51	39	117	1–10	$13\frac{1}{4}$	......	120	1.125×0.080 1×0.080	9,634	19,382
GE-70.......	40	2,785	$5\frac{1}{2}$	4	$4\frac{1}{8}$	86	17.69 19.67	15.71	22.64	37	111	1–10	$9\frac{5}{8}$	......	110	5 BWG	6,430	12,530
GE-67.......	40	2,425	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{5}{8}$	84	17.67	15.69	24.60	37	111	1–10	$9\frac{1}{8}$	$7\frac{1}{2}$	110	0.220	5,800	11,000
GE-66.......	125	4,425	$5\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	89	19.70	16.73	35.54	39	195	1–10	$14\frac{3}{4}$	......	85	$1\frac{1}{8}$×0.120 1×0.120	11,600	22,000

HARTFORD SHOPS—DATA SHEET ON TWENTY-FOUR TYPES OF RAILWAY MOTORS.—*Continued*

Motor	H.p.	Wght. with gear and gear case	Max. diam. of axle	Clearance above rail 33-in. wheel		Sum of gear and pinion	Gear ratio			No. coils in armature	No. com. bars	Throw of coils	Orig'l com. diam.	Safe wearing diam.	No. turn in field	Size of wire	Weight of equipment	
				Motor	Gear case		Stand	Min.	Max.								Two motors	Four motors
GE-57.......	50	3,002	$4\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{8}$	85	19.66	18.67	26.59	33	99	1-9	$10\frac{1}{4}$	$9\frac{1}{4}$	110	$0.035\times1\frac{5}{16}$	7,000	14,200
GE-54.......	25	1,861	4	$5\frac{7}{8}$	$4\frac{5}{8}$	81	14.67	14.67	14.67	29	115	1-8	$8\frac{1}{2}$	$6\frac{7}{8}$	$128\frac{1}{2}$	No. 4	4,650	8,500
GE-52.......	25	1,500	4	......	.....	84	17.67	15.69	24.60	29	87	1-8	8	$6\frac{7}{8}$	$155\frac{1}{2}$	No. 5	4,650	8,500
West. 101B..	40	2,730	5	$4\frac{1}{8}$	4	84	15.69 18.66 22.62	15.69	26.58	37	111	1-10	$10\frac{1}{4}$	$8\frac{3}{4}$	$110\frac{1}{2}$	0.078×0.625	6,600	12,500
West. 93A...	60	3,360	$5\frac{1}{2}$	$3\frac{3}{8}$	$3\frac{5}{8}$	87	16.71 19.68 24.63	16.71	35.52	45	135	1-11	$10\frac{1}{4}$	$8\frac{1}{2}$	$78\frac{1}{2}$	0.043×1.25	7,310	14,700
West. 92A...	35	2,265	5	$4\frac{5}{8}$	$4\frac{3}{16}$	84	15.69 18.66 22.62	15.69	26.58	41	123	1-10	9	$7\frac{3}{4}$	$125\frac{1}{2}$	0.078×0.5	5,570	10,500
West. 49....	35	1,920	4	$4\frac{3}{4}$	$4\frac{1}{8}$	82	14.68 18.64	14.68	24.58	59	117	1-14	$8\frac{3}{8}$	$6\frac{5}{8}$	114	No. 4	4,900	9,300
West. 12A...	25	2,270	4	$4\frac{3}{4}$	$4\frac{3}{8}$	82	14.68	14.68	14.68	47	93	1-12	$8\frac{3}{8}$	$6\frac{7}{8}$	187	No. 6	5,400	10,100
West. 12A...	30	2,200	4	$4\frac{3}{4}$	$4\frac{3}{8}$	82	14.68	14.68	14.68	47	93	1-11	$8\frac{3}{8}$	$6\frac{7}{8}$	187	No. 6	5,400	10,000
West. 12A...	30	2,270	4	$4\frac{3}{4}$	$4\frac{3}{8}$	82	14.68	14.68	14.68	47	93	1-12	$8\frac{3}{8}$	$6\frac{7}{8}$	187	No. 6	5,550	10,400
West. 12....	25	2,640	4	4	$3\frac{7}{8}$	82	14.68	14.68	14.68	47	93	1-13	$8\frac{3}{8}$	$6\frac{7}{8}$	187	No. 6	5,400	10,100
West1 3.....	25	2,600	4	$6\frac{1}{2}$	5	80	18.62	18.62	18.62	95	95	1-25	$8\frac{3}{4}$	$6\frac{7}{8}$	180	No. 8	5,400	10,100
West. 112....	65	3,411	6	$3\frac{3}{8}$	$3\frac{7}{16}$	89	16.73 20.69 24.65	16.73	35.54	45	225	1-11	$12\frac{1}{2}$	11	$60\frac{1}{2}$	0.062×1.25	8,000	15,750

NOTE.—GE-73 motor is 2 1/2-inch pitch gear. All others 3-inch pitch.

XI

CONTROL, CIRCUIT-BREAKERS, CONTROLLERS, RESISTANCES AND GENERAL TESTS

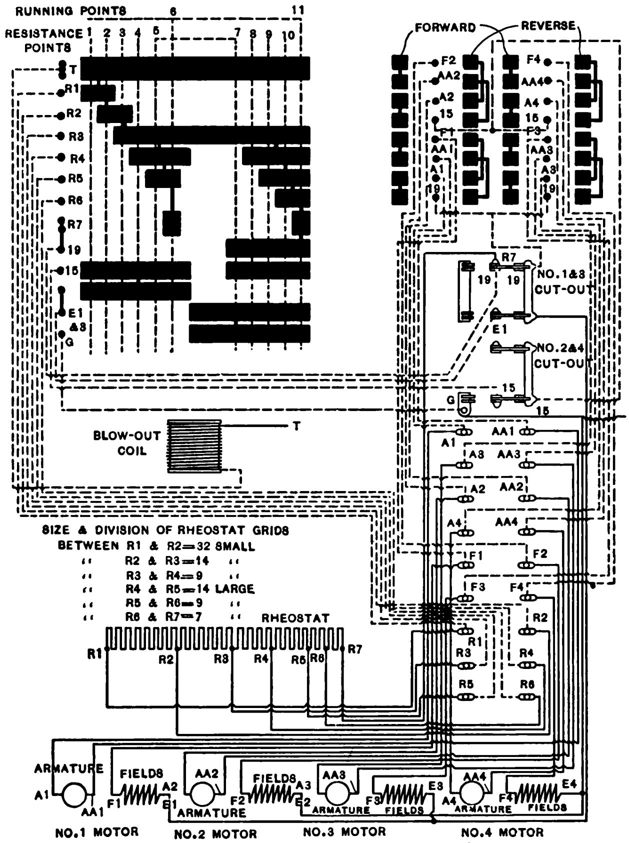
Controller Changes, Third Avenue Railway.—At the shops of the Third Avenue Railway, New York, an inexpensive yet important betterment has been made in the controllers by removing the old countersunk screws in the water collars of the main and reverse cylinders and replacing them by screws with a projecting head. This change was made to eliminate the difficulty of removing the cover due to the rusting of the countersunk heads. A No. 2 wire has been substituted for the original No. 4 T-2 terminal wires of K-11 and K-27 controllers, as the old wires were found to be of insufficient capacity for the heavy currents which are taken through these controllers. The blow-out coils of the same types have been furnished with sleeved terminals to permit the quicker insertion of the connecting wires.

Controller Maintenance in Brooklyn.—On the Brooklyn Rapid Transit System the cost of stripping a K-11 controller and replacing all worn material averages about $2.50 for both labor and material. Among the departures which have been made from the original design of this controller are the following: A board of 1/2-in. vulcabeston has replaced the 1/16-in. fiber barrier between the main and reverse cylinders; in addition to the single-arc shield above the trolley controller finger four arc shields have been installed; the binding posts have been changed to permit the screws to go in perpendicularly so that the wires are no longer cut by the threads as occurred when the screws were inserted at an angle to the wire; the back is treated with asbestos and shellacked and all wires and cables are also shellacked. It may be added that the controller contact plates are lubricated with vaseline at the regular inspections.

A Novel Arrangement of Motor Control.—The Cedar Rapids & Iowa City Railway & Light Company has several express cars which are frequently used for switching service. In order to permit motormen to observe signals given by a switchman from the rear during such movements the cars have been equipped so that the controller can be operated from either side of the cab. The arrangement, which has been developed by Charles Munson, electrical engineer of the company, consists in a bevel gear mounted in a cast-iron casing in place of the controller handle and operated by means of a horizontal shaft extending across the car.

The shaft is made of gas pipe and has a handle at each end equipped with a "dead man's button," so that a man seated at either side of the cab and leaning out of the cab window has a handle within easy reach. The reverse lever is arranged in the same manner with a horizontal rod attached to the reverse lever through a pair of bell cranks.

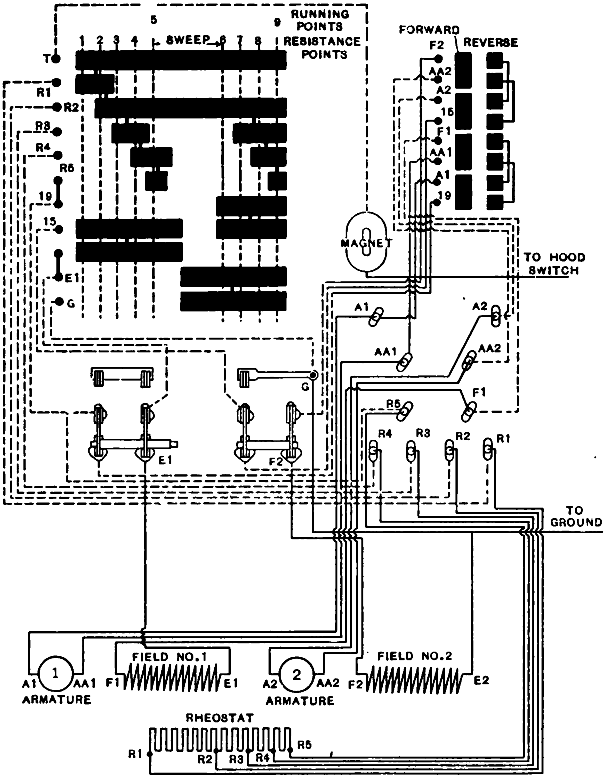
The cars are equipped with automatic air brakes for road service as well as straight air brake for use in switching. The straight air control



Connections for S. P. K-6 controller and rheostat for four GE-1000 or GE-67 motors, Toronto.

valve is connected by rods to hand levers on each side of the cab and within easy reach of the motorman, the automatic air being controlled through an engineer's brake valve in the customary position on the right-hand side of the cab. The control equipment is of the Westinghouse K-14 type, and a four-pole switch is provided in the motor circuit which enables the motorman to throw all four motors into series for starting an extremely heavy load.

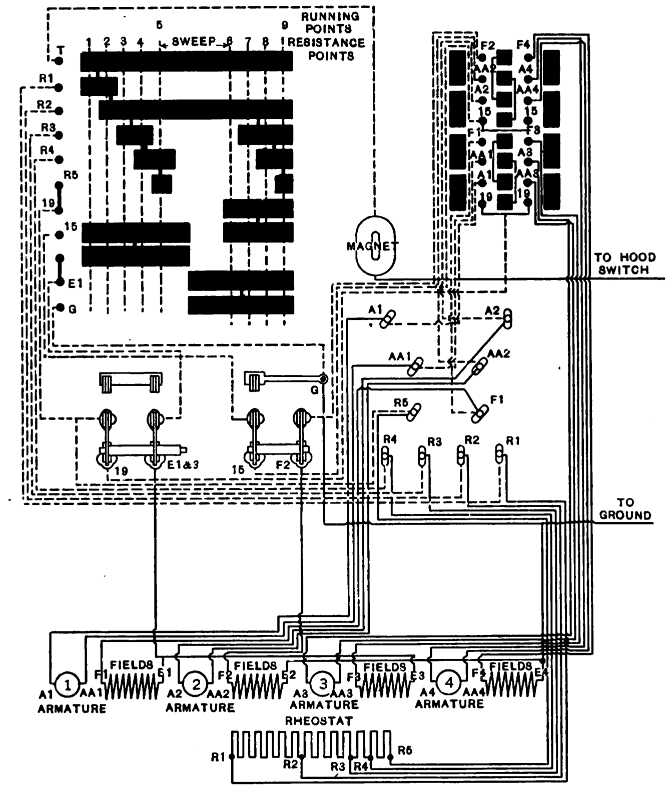
Controller Work at Toronto.—At the shops of the Toronto Railway, particular attention has been given to controller troubles, and, as a result, several changes have been made in construction. That portion of the controller case opposite the space between the main and reversing cylinders is covered with No. 16 fiber screwed down on wooden blocks and the cylinders are separated by a fiber barrier. In the K-6 controller, insulating barriers have been placed between fingers 15 and E, in addition to those between 19 and R-6 and 19 and 15, which were installed by the manufacturer. The controller board is also insulated with mica



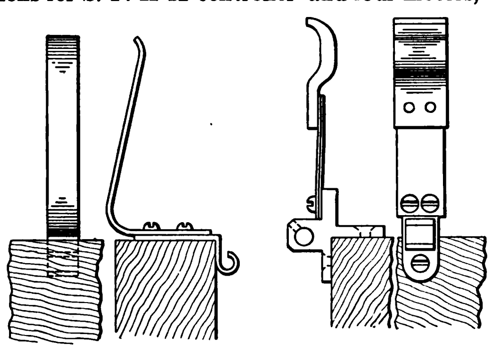
Connections for S. P. K-10 controller, Toronto.

from finger 19 to ground. Instead of carrying the ground wire from the ground terminal on the main board to F2, a wire is sweated to F2 and connected to ground on the main cylinder block. In all controllers the motor cutouts are plainly marked "1" and "2" to avoid errors.

Nearly all parts of the K-6 and K-10 controllers are interchangeable. Old segments and fingers are cut down for use again wherever possible. Every division is supplied with a bar bender to make segments from bars supplied by the shop storeroom. Fingers manufactured of phosphor bronze are used on the reverse cylinder at one-third the cost of the usual



Connections for S. P. K-12 controller and four motors, Toronto.



Two types of reverse fingers in controllers, Toronto.

drop forgings. All heavy filing or sand-papering is avoided in cleaning fingers, segments and cover plates, as such parts are simply dipped in lye and acid, then chamfered with a rough file and buffed.

One feature of the controllers is that they are not grounded, but are insulated on a wooden block, yet very little trouble has arisen from blow-outs and there have been no instances of shocks to the motorman. When the controllers go through the daily inspection they are blown out with compressed air, which results in keeping them so clean that there are no leaks or bad short circuits. In overhauling controllers the case is stripped down to the back, painted with black insulating paint on both sides and lined inside with asbestos, after which the interior is rebuilt. Three controller wiring diagrams are appended.

Simplified Controller Diagrams (By E. C. Parham).—A car-wiring diagram when reduced to a drawing of convenient size has so many wires running to points apparently close together that it is hard to follow even a regular circuit from beginning to end with any degree of certainty, especially for one not familiar with such circuits. The substance of this article is to show a conventional but simple method of representing a car-wiring diagram in such a manner that the effect of a ground, open circuit or wrong connection and the irregular circuit thereby established becomes almost evident.

Fig. 1 is a wireman's diagram of four motors, controlled by a K-6 General Electric controller, or its equivalent, and the path of the current established by the first controller notch is indicated by the arrowheads. It will be noted that the main controller fingers are represented by circles inked in black; the reverse fingers by circles with dotted centers; the cut-out switch posts by circles with crosses, and the connecting-board posts by plain circles. All controller wires which are installed at the factory are indicated by dotted lines, and all wires which are to be installed by the wireman are indicated by full lines, after the method used in standard factory diagrams.

Fig. 2 is a simplified reproduction of Fig. 1, and the conventional marks are so used that any given part of the circuit or all of it, as shown in either diagram, can be readily identified in the other. Fig. 2*a* is the circuit development for "series-ahead," Fig. 2*b* for "series-back," Fig. 2*c* for "parallel-ahead," and Fig. 2*d* for "parallel-back." The most convenient layout for using such diagrams is to draw them on a slate so that connections may be readily erased and replaced by those to be studied. Thus the diagrams show clearly the effect, so far as the circuits are concerned, if the $F1$ and $A2$ wires are confused when the controller is connected up. They also illustrate the different conditions established when the controller is "ahead," "back" or in "series" or in "parallel." With an ordinary diagram satisfactory study of irregularities in a car circuit is difficult because of the trouble which most people experience in holding such circuits as a whole in mind. With the diagrams submitted

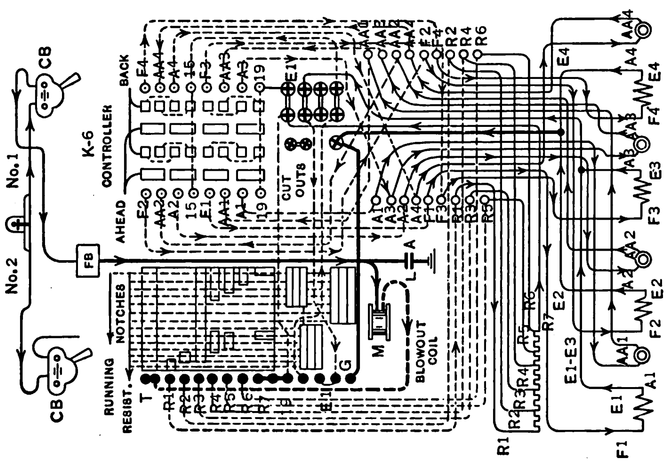


Fig. 1.—Ordinary controller diagram.

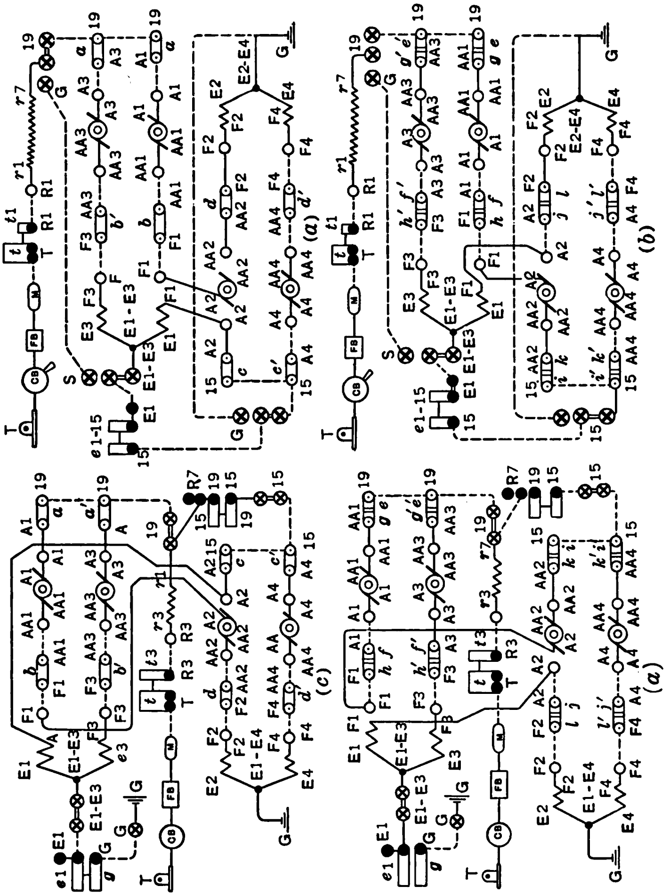


Fig. 2.—Simplified controller diagram.

all complications disappear and only a knowledge of the law of current preference is required.

Montreal Apparatus for Testing Circuit-breakers.—The apparatus shown in the accompanying drawing has been installed in the Youville shops of the Montreal Tramways to test and set circuit-breakers while in position on cars. Current is used at 600 volts because a circuit-breaker which will successfully break a heavy current at low voltage will not necessarily break it at trolley voltage. The apparatus is mounted on the wall beside the most accessible shop track, and circuit-breakers in any car on this track can be readily tested.

All circuit-breakers which are sent to the carhouses to be there mounted in cars are first tested by means of this apparatus, as well as all circuit-breakers mounted in the cars before they leave the shops. The unmounted circuit-breakers are clamped to a bracket on the wall.

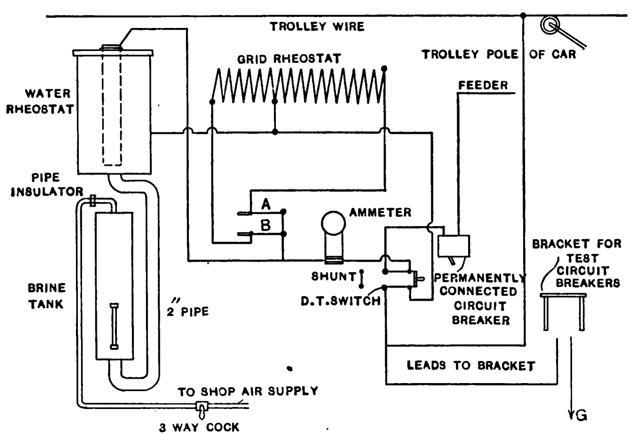


Diagram of wiring connections for circuit-breaker testing, Montreal.

This bracket is so arranged that the circuit-breakers are clamped in the same position as in the cars. This is a necessary precaution because in some types of circuit-breakers the weight of the armature is so great in comparison to the pull exerted by the calibration spring that the position of the circuit-breaker materially affects the calibration. The leads for use in connection with this bracket are shown in the accompanying diagram. The source of current is a shop feeder, and when the apparatus is not in use this feeder is connected direct to the trolley wire by means of a double-throw switch.

Referring to the diagram, it will be seen that when the knife switches *A* and *B* are closed, the current after passing through the ammeter shunt follows three parallel paths; that is to say, the two legs of the grid rheostat and the water rheostat. The capacities of the two legs of the grid rheostat are 200 and 100 amp. respectively and the water rheostat will carry a maximum of 200 amp., making a total capacity of 600 amp.

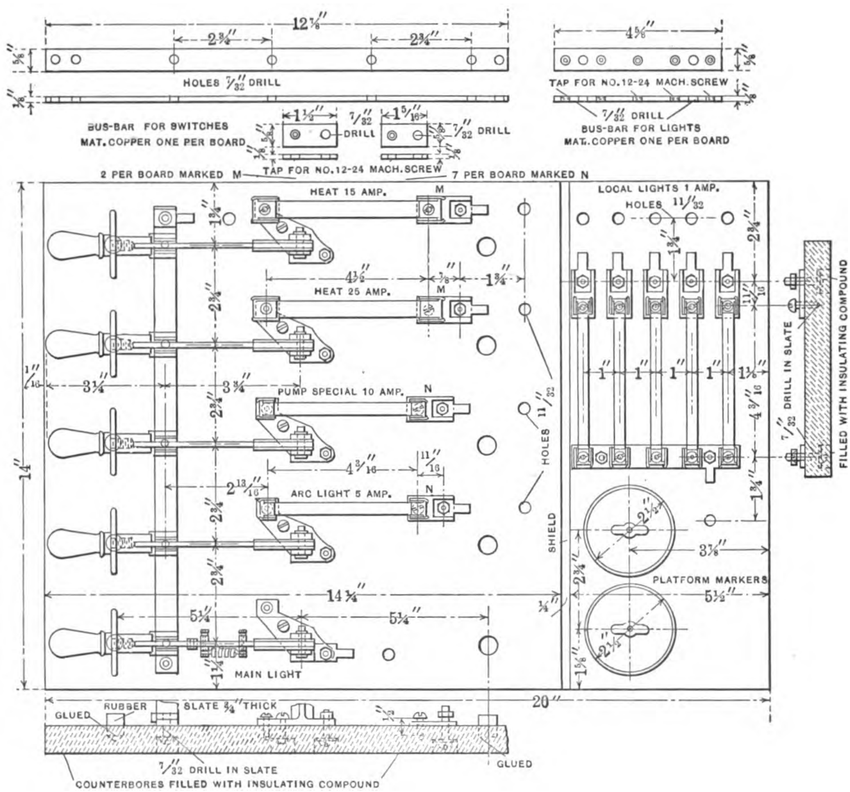
The novel feature of this apparatus is the utilization of the shop supply of compressed air to pump brine into the water rheostat. The regulation of the current in this rheostat is found to give ample range of adjustment. This water rheostat is made of an old transformer oil tank in which a 6-in. iron pipe is suspended to form the positive electrode. The lower tank which contains the brine is an old air reservoir with a water gage added. The air is controlled by a three-way cock. It passes into the top of the brine tank, thus forcing the brine up into the rheostat. To empty, the air in the brine tank is exhausted to the atmosphere and the brine runs back by gravitation. The water rheostat and the brine tank are mounted on wooden supports to insulate them from the ground. The air pipe leading into the brine tank is insulated from the tank by a pipe insulation.

In testing circuit-breakers mounted in cars the current after passing through the rheostats goes to the trolley wire and from there to the circuit-breaker in the car. A jumper is placed from the trolley finger to the ground finger of the controller, thus enabling the current to flow directly to the rail. The apparatus is of simple construction and inexpensive. It gives very satisfactory service.

Changes in Multiple-unit Control Circuits at Brooklyn.—Several important changes which add greatly to reliability and safety in service have been made during recent years by the Brooklyn Rapid Transit System in both the main and auxiliary circuits of the multiple-unit control systems on elevated cars.

Formerly the batteries were charged through the lighting circuit so that charging occurred only when the lights were on. This method proved particularly unsatisfactory in the short summer season when an average of 250 to 300 weak batteries a month was reported. The batteries are now charged from the compressor circuit, the current passing through sufficient resistance to secure the desired maximum of 2 amp. to 3 amp. The resistance can be changed to have the rate of charging vary according to the type of control. The resistance to ground is merely one shunt of the circuit in which the battery forms the other shunt. A relay in this circuit opens the battery circuit whenever the compressor is not operated, thus preventing the batteries from discharging through or, in other words, attempting to operate the compressor.

Another battery change was to place in parallel all batteries on cars equipped with the old drum-type controllers. The batteries on each motor car were formerly connected to a single train line, the opposite terminal of each battery being grounded. In operation, however, it was found that if any set of batteries on one car was weaker than the others there would be a reversal of current because the high-voltage batteries would try to charge the low-voltage battery, thus reducing the available train-line voltage. The evil was corrected by placing all batteries in parallel so that their differences in voltage would always be equalized. This end was accomplished by so changing the connections in the control circuit that an additional train-line wire was obtained to serve as the battery minus wire. The availability of a wire for the battery minus circuit was due to the fact that a wire which had previously been in the



Layout of switchboard for cabs, Brooklyn.

reverser circuit was now utilized in the operating circuit by placing an interlock on the reverser. The change in train wiring was directly associated with the general alterations made to permit the interoperation of the older and newer types of automatic control. Formerly the unit switch group type of control could not be operated with the older drum type because the seven wires of the train line did not perform the same functions. Consequently, the circuits in the older type were rearranged so that the corresponding train-line wires of both systems would have the same duties.

The second important change in the drum-type control was the installation of the limit switch in series with the armature and field of No. 2 motor, instead of placing it in a shunt around the field of this motor. One trouble with the shunt connection was that the switch was frequently out of adjustment owing to the difficulty of maintaining the proper ratio of current division, for since the shunt carried a small current it was more easily affected by minor variations in voltage than if placed in the series circuit. The shunt limit switch also gave trouble in case of an open circuit in the armature of No. 2 motor, for in that event there was the possibility that all current would go through the switch and burn it up. Of course, when connected in series, the limit switch is also on open circuit when the rest of the equipment is.

A third change in the drum-type control was the substitution of a line switch in place of a circuit-breaker. Formerly when dropping off the main motor circuit in this control was opened directly at the controller, thus causing the burning of fingers and contacts. Controller explosions were also possible on account of short circuits. These controllers are mounted above the floor level in a compartment adjacent to the motorman's cab, and it was therefore considered desirable to eliminate defects of this character. Consequently a line switch was installed to open the circuit independent of the controller. This line switch is placed in a box underneath the car, where its operation cannot disturb the passengers. It not only serves to open up a circuit during ordinary operation, thereby taking the arc away from the controllers, but it also replaces the circuit-breaker as a means for opening the circuit on over-loads.

The release safety switch cylinders of Westinghouse 131 and 160 control have been drilled to secure air connections which insure uniform acceleration throughout the train even when cars with old and new types of automatic control are operated together. This change was made because the old controller gave considerable trouble from what is termed "hanging up" owing to the sluggishness of the repeating switch in cases where the motorman desired to secure a quick release. The trouble was that the operating pawls would fail to complete their forward stroke for advancing the controller drum before the rack and pinion of the release cylinder was at work pushing in the contrary direction. The consequence was a wedging action at the star wheel. The control equipment is now so interlocked that air cannot enter the port of the release cylinder until the interlocking circuit for the operating cylinder has been opened.

The large detail drawing on page 154 shows the slate panel switchboard in the motorman's cab of the elevated cars. Formerly transite-lined boxes with a board equipped with snap switches were used for this purpose. The new outfits are better constructed, better insulated, use knife switches instead of snap switches to secure greater mechanical efficiency, and, furthermore, the back of the box is arranged so that every wire can be easily inspected when desired.

Improving Resistances in Brooklyn.—Since 1911 the Brooklyn Rapid Transit System has been working toward the elimination of old-type grid resistances with the object of standardizing the installations on 272 single-truck cars of open and closed types, 507 double-truck closed cars, 750 double-truck open cars, and 563 double-truck semi-convertible cars. This list embraces more than one-half the surface rolling stock in service. The new equipments are of the Westinghouse three-point suspension type. The old resistances had sixty grids, but although the new ones have only forty-eight their total capacity is greater. The resistance steps have been so arranged that the current on the first notch will be low enough to

RESISTANCE STEPS FOR DOUBLE-TRUCK CARS WITH TWO MOTORS, K-11 CONTROLLERS AND THREE-POINT SUSPENSION RESISTANCE

Point	Connection	Ohms
1	R_1 to R_5	4.416
2	R_2 to R_5	2.40
3	R_3 to R_5	1.12
4	R_4 to R_5	0.48
5	Full Series	All out.
6	R_2 to R_5	2.40
7	R_3 to R_5	1.12
8	R_4 to R_5	0.48
9	Full Multiple	All out

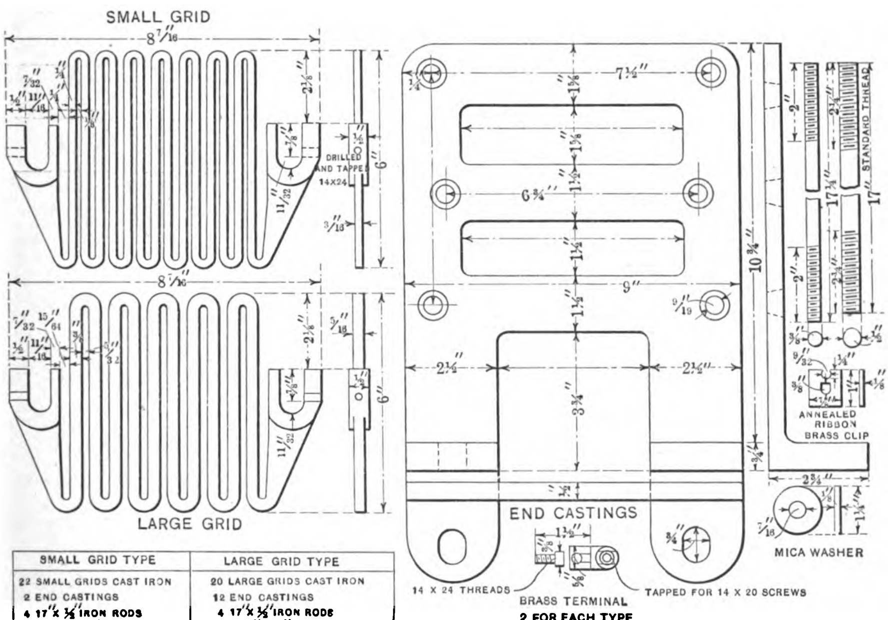
WESTINGHOUSE THREE-POINT SUSPENSION RESISTANCE GRIDS USED ON DOUBLE TRUCK CAR WITH TWO MOTORS AND K-11 CONTROLLERS

From	No. of grids	Pattern No. of grids	Resistance each, ohms	Total resistance, ohms	In circuit on points
R_1 to R_2	16	N-3210	0.126	2.016	1
R_2 to R_3	16	N-3353	0.08	1.28	1-2-6
R_3 to R_4	8	N-3353	0.08	0.64	1-2-3-6-7
R_4 to R_5	8	N-3354	0.06	0.06	1-2-3-4-6-7-8
				4.416	

avoid jerky starts. In series running the maximum current will be obtained on the third point, and in parallel running on the last point, notching at the rate of one second per point. The accompanying tables show the resistance steps for double truck cars with two motors, K-11 controllers and three-point suspension resistances, the total amount of resistance in circuits at various points and other data.

The new installations are being made on a renewal basis only. The old resistances removed are being used for the maintenance of other cars which are still equipped with the old types.

Resistances with Removable Grids.—The accompanying illustration shows the detail construction of a small and large grid resistance made by the Toronto Railway after the models of the Detroit United Railway. These grid resistances are arranged to give a first-step resistance of 5 3/4 ohms on single-truck cars and 3 ohms on double-truck cars. The rheostats are built so that broken grids can be removed without disturbing the others. This is done by slackening the outer and inner end bolts on the middle micanite tubes and the individual screw at the side. The



SMALL GRID TYPE	LARGE GRID TYPE
22 SMALL GRIDS CAST IRON	20 LARGE GRIDS CAST IRON
2 END CASTINGS	12 END CASTINGS
4 17" x 1/2" IRON RODS	4 17" x 1/2" IRON RODS
2 17 3/4" x 3/8" " "	2 17 3/4" x 3/8" " "
16 1/2" HEXAGON NUTS	16 1/2" HEXAGON NUTS
8 3/8" " "	8 3/8" " "
25 MICA WASHERS	23 MICA WASHERS
21 BRASS RIBBON CRIPS	19 BRASS RIBBON CLIPS
42 1/2" x 14" x 24" MACHINE SCREWS	38 1/2" x 14" x 24" MACHINE SCREWS

Details of removable grid resistance, Toronto.

3/8-in. micanite tubes which carry the grids are insulated by mica from the end casting. Brass ribbon clips are used to insure good contact between the connecting ends of adjacent grids, and mica washers are employed on the opposite ends.

Resistance Adjustment at Indianapolis.—At the shops of the Indianapolis Traction & Terminal Company, car resistances are adjusted in accordance with the following table. The quantities quoted in this table for each resistance step are based on the use of a constant testing

INDIANAPOLIS SHOPS—TABLE USED IN ADJUSTING RESISTANCES

Motors	Control	Weight of car	Dwg. No	Connections	Volts
2 GE.-800 2 West.-3 2 West.-49	K-2 K-10	11-tons	746	R_1–R_5	66½
				R_1–R_4	63
				R_1–R_3	52½
				R_1–R_2	34
2 West.-56	K-11	20 tons	747	R_1–R_5	38
				R_1–R_4	34½
				R_1–R_3	29
				R_1–R_2	20
2 West.-93A_2	K-11	20 tons	748	R_1–R_5	38
				R_1–R_4	35
				R_1–R_3	31
				R_1–R_2	24

current of 10 amp., and thus the readings are in volts rather than in ohms. A current of 10 amp. is not sufficient to heat the grids and therefore no correction for hot resistance is necessary. The use of constant current makes the calculation in voltage a simple matter because, with the testing current of 10 amp., the voltage reading at any step along the series of resistance connections equals 10 times the ohms resistance in the circuit, and it is only necessary to read the voltage and move the decimal point one place to the left to obtain the ohms resistance of the circuit.

Calculation of Resistance and Rate of Acceleration. *Query.*—If a car is to be built to weigh, say, 30 tons, including electrical equipment of four GE-80 60-h.p. motors with K-28-B control, how could the resistance be calculated with such exactness that there would be an easy start on the first point, and so that the arcing when the controller passed from the first point to the off point would be reduced to a minimum? Another problem which the writer would like to have solved is the following:

If a car with certain low-speed gear ratio accelerated smoothly on level track and even up a 15 per cent. grade at 500 volts, would not the acceleration be poorer if the gear ratio was changed for higher speed and the other conditions remained the same? Would the wheels tend to spin more because the higher speed equipment required a larger starting current and hence less external resistance? Why is it that the higher speed equipment requires a larger starting current and must have a finer rheostatic adjustment to reduce the spinning tendency to the minimum?

Reply.—The total amount of grid resistance for use with the equipment and weight of car specified would depend on the initial acceleration desired. An acceleration of 1.5 m.p.h. per second is a common figure used for ordinary service conditions. A tractive effort of 100 lb. per ton is needed to produce an acceleration of 1 m.p.h. per second. Hence there must be $1.5\times100\times30$, or 4500, lb. net tractive effort for a 30-ton car. The train resistance for the slow speed of starting will be about 20 lb. per ton, or 600 lb. for a 30-ton car. The total tractive effort developed by the motors in starting must therefore be $4500+600=5100$ lb., or 1275 lb. per motor for a four-motor equipment. By referring to a characteristic curve for a GE-80 motor with 4.73 gear ratio and 33-in. wheels, it will be seen that this required tractive effort is produced when each motor is taking 62 amp. With the motors connected in pairs with two motors permanently in parallel, as would be the case with a K-28-B controller, the total car current would be 124 amp. By Ohm's law the line potential of 500 volts divided by this current would give 4.03 ohms as the total resistance of the circuit. The resistance of four GE-80 motors connected as above is 0.574 ohm, and if the resistance of the car wiring and inductive effect is 1.4 ohms, this would leave 2.056 ohms as the value of the grid resistance. Several methods are employed by designers for computing the values of the various resistance steps after the total resistance has been determined.

A car with the weight and equipment just mentioned will have a maximum speed of about 24 m.p.h. on a level track. If this gear ratio should be changed from 4.73 to 3.53, the maximum speed will be increased to 30 m.p.h. If the accelerating current remains the same, the average acceleration will decrease from 1.5 m.p.h. per second to 0.93 m.p.h. per second, due to the decreased tractive effort with the same current at the lower gear ratio. If it is desired to keep the average acceleration the same, then the accelerating current must be increased from 62 amp. to 82 amp. per motor, to give the same tractive effort in each case. The rate of acceleration is limited by the weight on the driving wheels. Under ordinary track conditions, if the tractive effort developed is more than one-fifth of this weight, the wheels will slip. Thus in the case in question the tractive effort should not be over 3000 lb. per motor. With the equipment as specified, the motors would have to be very much overloaded to slip the wheels. A careful study of the characteristic curves for the motors used on any equipment will show how a change in gear ratio will affect the speed, acceleration and tractive effort.

Installation and Connection of Grid Resistances (By H. Schlegel).—If we assume that we have a set of grid resistance frames well selected and correctly made, the next chance for fault and confusion is in their installation and connection—and faulty installation often begets faulty connection. The frames should be placed well away from the car floor, well away from the water and slush to be thrown by the car wheels, and well clear of all brake parts. By the latter I mean under all conditions, that is, whether the brakes are applied or released, whether the car is light or loaded, and whether it is in a curve or on a straight rail or on no rail at all, and in all these cases allowance must be made for extreme travel of brake rods and chains due to neglect, slack and wear.

Secondary considerations in the location of the resistances are (*a*) that the frames shall be so placed that the heat of one frame shall not blow through the others when the car is in motion; (*b*) that the frames shall be located in the same order on all cars, and (*c*) that the individual placing of frames be such that the minimum length of jumper will connect the correct end of one frame to the correct end of the frame next to it. With conditions (*b*) and (*c*) observed, the right or wrong disposal of a frame can be judged at a glance.

The height above the rails and the space available under different car bodies vary so in amount and disposition that no rigid rule can apply to all. On modern grid frames the length of the legs is such that the resistance metal is held a safe distance from the asbestos-lined car floor even when the legs are lagged or bolted directly to the car floor, provided a proper selection of grids prevents excessive heating; but this direct connection of frames to car floor, especially by through bolts, is to be avoided, because in event of defective grid-to-frame insultation or of a frame picking up wire in the street—and this often occurs—the through bolts become charged and create in the car floor above a charged area ready to shock a passenger making contact with it and a grounded area at the same time. The safest method of suspension is by means of the hangers supported at points where their fastening bolts will not be within reach of passengers' feet inside the car. A good method and place of suspension, where such is practicable, is to use hangers of L section which extend on either side of the short circuit line of the car, the resistance frames being placed lengthwise along the shorter center line. This arrangement has the advantage that the sides of all frames are exposed to the direct windage due to motion and the hangers are supported from the sides where the liability to cause shock is the least. On cars with centerhung brake levers, the frames must be dropped as low as permissible and the brake rigging allowed to work between the top of the hanger and the bottom of the car. A wood or fiber guard should then be placed above the hangers on both ends to prevent any contact between the sway bar and the hanger.

Assuming that the frames have been so assembled and the sectioning so proportioned that all car wires must be brought down to the same side of the frames, care must be taken that all frames are installed with their connecting sides toward the same hanger iron. If this is not done, not only will some of the car wires have to cross over or under the frame, but a long jumper instead of a short one will have to be used, thereby making the connections appear confusing. Where the manner of assembling has not been thus standardized, it will in all cases pay to do so. The turning of a coil end for end would then become detectable at once, and this is a mighty good feature, especially on frames composed of two or more different kinds of grid. The effect of getting such a frame end for end is to put high-resistance grids of high-current capacity where low-resistance grids of high-current capacity should be, with the final result that the car will notch in jerks and the abused frame will give trouble. Measurement of the total resistance of the starting coil will not reveal this condition, because unless the jumpers are so run as to cut out some grids the total resistance will measure normal. The wiremen should be made to understand that jumpers between frames should be so run that current entering at one end of the starting coil must traverse every grid of every frame before leaving at the other.

The above points by no means include all of the irregularities encountered in the careless assembly, installation and connection of grid starting coils, but are sufficient to emphasize the importance of using a standard grid, assembled in a standard frame and installed and connected according to standard methods.

Construction of Grid Starting Coils (H. Schlegel).—The unit into which resistance grids are assembled is called a "box" or "frame." To assemble a box or frame correctly is easy; to assemble one incorrectly is equally easy, as inspection of several hundred in operation will show. The master condition of assembly is that current entering at one end of the frame shall traverse every grid before leaving at the other end. As simple as this condition may seem, it is too often ignored either through fault of the man who assembles the frame or that of the man who connects it to other frames under the car. Construction faults only will be considered here.

1. The frames must be sound and straight; the grids must have no cracks, warps or burrs and should be of standard resistance per grid. Factory-made grids meet these conditions; locally made grids may or may not, especially in the matters of resistance and thickness through the grid eye. The thicker the grids, the greater the trouble to get the required number into the given length between the end plates. If this length is increased it will be at the risk of having to drill new holes in

the resistance hangers. Grids of the right resistance are the result of experience and trial in making the patterns from which they are cast. The manufacturing companies have passed through the necessary experimental stage and anyone wishing, in a hurry, grids of standard resistance will do well to avoid home talent until the hurry shall have passed.

2. The contact surfaces of adjacent grid eyes should be squared with the hole through which passes the mica insulated rod on which the grids are assembled, otherwise when the frames are tightened, the lower ends of some of the grids will be drawn toward each other, with the resulting possibility of contact when the grids heat and expand. Final tightening of the frame should be done in a horizontal position so that the grids hang vertically; this will avoid a general deflection of the grids toward one end of the frame where the tendency to flash over is greatest. Fig. 1 is an exaggerated side view of part of a frame that was tightened while

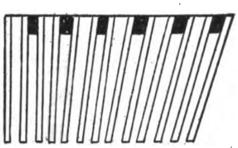


Fig. 1.

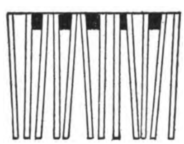


Fig. 2.

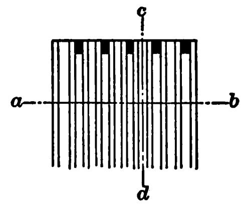


Fig. 3.

resting on end. Fig. 2, of a frame composed of grids not squared to the hole. Fig. 3 indicates part of an assembly correct in both respects—center lines *a–b* and *c–d* are square with each other.

3. When terminal eyes for the car connections are cast in the grid and a set of frames is composed entirely of such grids, the responsibility of connecting the car wires to the frames in the correct relation does not rest with the assembler; where separate terminals are assembled with the grids, however, the assembler can make mistakes which will cut out one or more grids, according as the grids are assembled in series or in parallel. If in series, there will never be more than two grids between mica washers; if assembled two or three in parallel there will be four or six between mica washers, except at the two starting places on the ends of the frame. Fig. 4 shows a top view of a frame composed of ten grids with terminals "*a*" and "*b*" so arranged that current entering at *a* must traverse every grid to leave the terminal at *b*.

To bring the terminals further from the end plates and thereby reduce the chances of a flash to the frame, it is customary to insert the terminals in the positions indicated by the dotted lines *z* and *y*. It will be noted that the first mica washer still comes between the terminals and the second grid on either end. In shop practice the mistake is often made of inserting the terminals on the opposite side of the mica washer, the result being to cut out two grids on each end of the frames. If the terminals are inserted at the places indicated by the double arrow heads, the result is to cut out one grid on each end of the frame. Where the abused section contains many grids in series, the result is not so serious, but in parallel frames it will cause unequal division of current and not only will the frame deteriorate, but the effect will be felt in the controlling notching.

Fig. 5 shows a frame composed of twelve grids so assembled that the current enters at one end and traverses the grids two in parallel; in

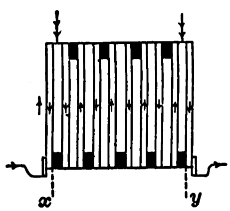


Fig. 4.

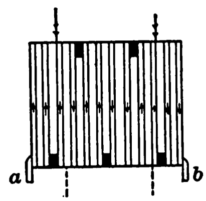


Fig. 5.

this case, except at the ends, there are four grids between every pair of mica washers; this follows from the fact that since the current zigzags across the frame two grids at a time, on that side where two pairs come together, there must be four grids. These characteristics are useful in telling at a glance whether a frame is a series frame or a parallel frame, or, in General Electric parlance, whether it is an A frame or a B frame. With the terminals at *a* and *b* current entering at *a* crosses over on the first two grids, returns on the second two, recrosses on the third two, comes back on the fourth two, goes over on the fifth two to come finally to terminal *b* on the sixth two after having traversed every grid in the frame. The terminals can be inserted anywhere between the positions indicated and the first mica washer on the same side because those points are electrically the same. If the terminals are inserted at the points indicated by the dotted lines, the result will be to cut out four grids on each end; if inserted at the places indicated by the double arrow heads, a very common mistake, the result will be to cut out two grids on each end. The cutting out of a few grids may amount to little or much; inasmuch as the grids are there and there for a purpose, they should be connected to be active—otherwise leave them out to make room for more insulation.

Assuming that a frame is to be composed of a number of grids in series, for current entering at one end to pass through all grids before leaving at the other, any two adjacent grids must touch or be otherwise connected on one side of the frame, but on the other side of the frame, they must be separated by an insulating washer. If the grids are supported by a third insulated rod passing down the center of the frame, every grid should be insulated from the grid next to it. So far as the frame itself is concerned it is immaterial on which side the first mica washer is inserted. In laying out a starting coil to be composed of several frames that are to be connected, however, it is desirable that the connecting jumpers between frames shall be short and straight; in such a case the frames must be assembled to suit the local conditions, otherwise it will be found impracticable to arrange them so that terminals that are to be jumped together will be next to each other under the car. Many conditions are simplified by so sectioning the complete starting coil that all terminals will be on the same side of the coil. This obviates the necessity of machining more than one side of the grid, makes it possible to have a neat, safe connection under the car and minimizes the chances of a wrong connection. If the frames are composed entirely of grids having terminals and but one or two kinds of grids are used and these are assembled into adopted standards, only one or two kinds of frames will be needed to meet the demands of all manners of equipment.

Having completed a frame, it should be suitably marked with a tag under one of the nuts or with a name plate. The G.E. method of designating frames is a good one because it is descriptive. The G.E. grids are numbered by casting; for example, one grid of a certain section is called 26,507, another smaller one of half the resistance per grid is numbered 26,510 and so on, the resistance per grid approximately doubling every third smaller number and having every third larger number after the manner of the B. & S. wire gage. If a G.E. frame is composed of twenty-four grids of the section known as 26,511 and the grids are all in series, the complete frame would be marked 11-A-24; the 11 indicates the size of the grid, the A indicates that all of the grids are in series, and the 24 that twenty-four of the grids are used. If the twenty-four grids were assembled two in parallel and twelve in series, after the manner of Fig. 5, the complete frame would be designated and marked as 11–B–24, the B indicating the grids to be assembled in parallel. The same method can be applied to the Westinghouse frames: thus a frame composed of twenty grids of Westinghouse section No. 7468 in series, would be marked 68–A–20; a frame composed of twenty grids of section 2119 ten in series and two in parallel, would be marked 1–B–20 and so on.

Resisters for Street Railway Service (By F. W. Harris).—The calculation of the necessary resistance and amount of resistance material in connection with ordinary street railway service is based on the hourly rating of the motors in horse-power. It is generally assumed that an amount of resistance should be used that will allow the hourly rating current to flow in the motors on the first notch of the controllers. A method of arriving at this value is given in the following paragraphs.

The first factor to be considered is the resistance of the motors themselves. This may be assumed as the average hot resistance of any line of

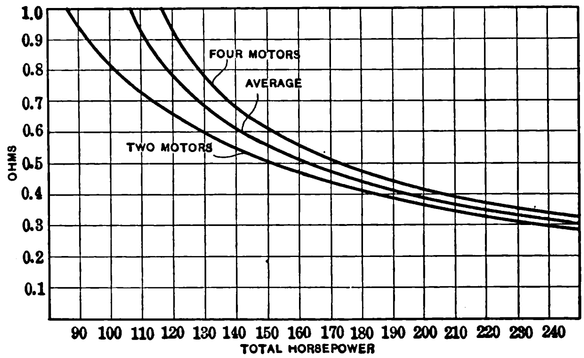


Fig. 1.—Resistor design—method of determining average motor resistance.

motors, as the values for all motors now on the market are sufficiently near for the purpose. A close degree of accuracy is not necessary for this work. There are in general use both two-motor and four-motor equipments which cover a wide range of horse-power. Hence it is desirable so to calculate the resistance that it will be available for either two-motor

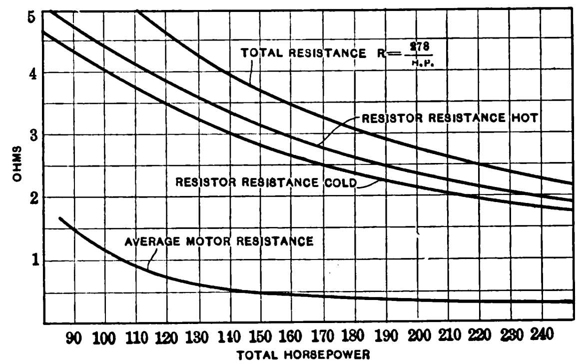


Fig. 2.—Resistor design—method of determining required grid resistance.

or four-motor equipments. Fig. 1 gives the curves for these combinations and from these is derived an intermediate curve shown as the average or mean curve. This curve is also an approximation, but it is close enough for the purpose.

The hourly current rating will flow in case the resistance equals 278 divided by the horse-power on the hourly rating basis. The hot resister resistance is given by plotting the mean motor curve from Fig. 1 and subtracting the values of the mean motor resistance from the total resistance. For cast-iron grids an average increase of 10 per cent. in resistance value when hot may be expected, and deducting this gives the value of the cold

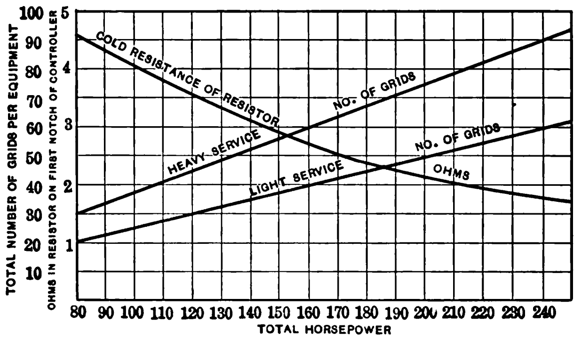


Fig. 3.—Resistor design—number of grids required for different services.

resistance. This represents the total resistance of the resister, cold, on the first point of the controller.

The number of grids will vary directly as the horse-power and will be different with different designs of grid. In standard grids now used by the large manufacturers of railway equipment it is often figured that about 4 h.p. per grid may be allowed for light service and about 3 h.p. per grid for heavy service. This practice varies with different manufacturers

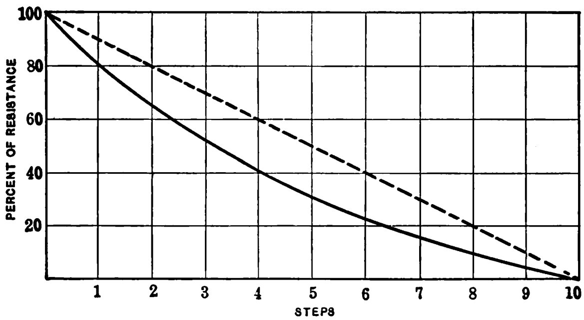


Fig. 4.—Resistor design—proportions for different steps on controller.

but is about as given in all applications. In Fig. 3 are plotted the total resistance and the number of grids, these representing average conditions as found in practice.

The proportioning of the various steps has been the subject of some deep investigation, but it becomes comparatively simple in practice.

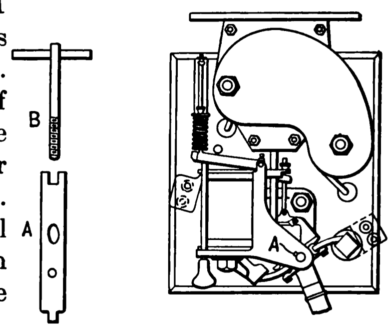
Since the object desired is to accelerate the car smoothly, the motorman is really the controlling factor, because the character of acceleration depends on the time interval. In fact, the men soon learn to manipulate almost any combination within reason. It is desirable to figure that the motorman will pass over the resistance notches in equal time intervals, but a small variation will not be noticed.

The most practical method for planning this is to make a curve as in Fig. 4. Here the percentages of resistance in circuit at any time are laid out vertically and the number of steps horizontally. In this instance ten controller steps are assumed.

The straight inclined line shown in the figure is a guide to the eye in drawing the curve, which may be done in about the proportion shown. This represents the resistance in circuit on any notch of the controller, the actual steps being found by subtraction.

In practice it will be found difficult to get the terminals conveniently placed if too much attention is paid to getting exact resistance values, and also that it is not advisable to be too particular about these values, because a wide variation from the calculated values, even 15 per cent., is rarely noticeable in the performance of the car under ordinary conditions.

To Remove Brushes on GE-Circuit Breakers (By G. M. Coleman).—It has been my experience when repairing the brushes on the General Electric circuit-breakers that the shaft *A* on top of the bearing is cut flush, as shown in the accompanying illustration. It is therefore impossible to get hold of it when repairs are to be made. The shaft is generally tight from rust or other causes, and is taken out with difficulty. To remove the shaft the magnet coil must be taken off. As the nuts are on the back of the breaker, the entire breaker must be removed from the car. This causes considerable work and necessarily entails much waste of time. To overcome the difficulty, tap out the end of shaft *A* for a 5/16-in. screw. A small hand wrench can be made by cutting a thread on a 5/16-in. rod, as shown in *B*. Then drill a 3/16-in. hole about 3/8 in. from the top of the rod and insert a 3/16-in. bar about 3 in. long to make a good hand hold. This wrench is screwed into shaft *A*, and the shaft is easily pulled out. After all the shafts on the different breakers have been tapped out in this way it is a very easy matter to remove them at any time.



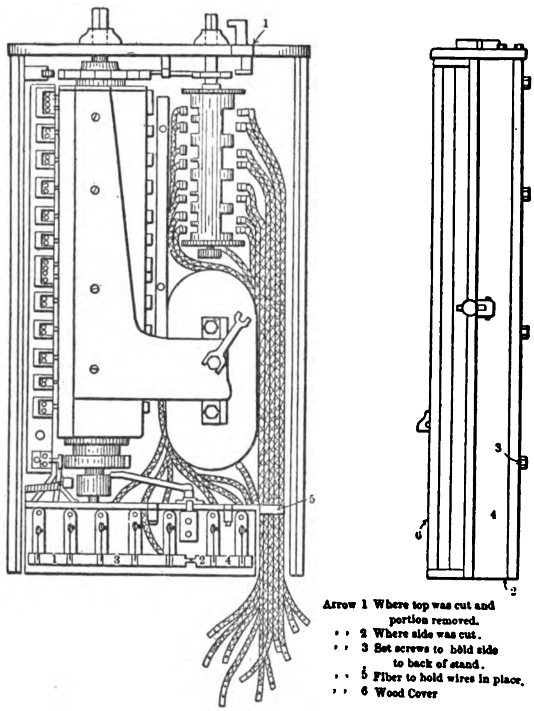
Device to remove shaft of circuit breaker.

Addition of Mechanical Reverser Throw.—The Interurban Railway Company, Des Moines, Iowa, has equipped its cars with a mechanical connection between the master controllers and the electrically operated reversers of the type *M* control. J. E. Welsh, master mechanic, relates the following as a reason for the added mechanical connection:

On one occasion the trolley pole on an interurban car broke while the car was running at a good speed. The motorman then applied the air and the main brake rod also broke. At this time the car was on a down grade and it was not stopped until it had run 8 miles, because the reversers could not be thrown. Fortunately, the motorman on an opposing car saw the runaway car approaching when it was a long distance away but coming toward him at a fairly high speed. He immediately reversed his car, running it backward just as fast as he thought safe with the trolley in the reverse position. The runaway car finally overtook the car that was backing up and bumped into it, but little damage was done to either car. Both were alike and had heavy M.C.B. couplers.

The possibility of the occurrence of such an accident brought about the addition of the mechanical reverser to the cars equipped with type *M* control. All of the cars are built for single-end operation and the reverser is placed under the right-hand side of the body. A crank made of fiber 1/2 in.×2 in. in section and long enough to afford ample clearance, is fixed to the spindle of the reverser. From the end of this crank a flat bar of iron 3/8 in.×1 in. in section extends to a bell crank under the front end of the car at the right-hand corner. Another rod connects this bell crank with a similar one under the left-hand front end of the car and this crank in turn is connected with a 7/8-in. rod which extends up into the motorman's cab, as far as the left of the controller. To the upper end of this rod a lever is attached parallel with the reverse handle and these two are connected by a link made of 1 1/4-in.×3/8-in. iron, the length of which depends upon the distance apart of the lever at the top of the 7/8-in. vertical rod and the reverse handle. By this train of parts the reverser is thrown mechanically as well as electrically.

Simplifying the B-8 Controller by Eliminating the Braking Feature (By A. H. Osterman).—Some years ago when the writer was in charge of controller work for the Lake Shore Electric Railway, Cleveland, Ohio, he was requested to simplify the wiring and reduce the size of some GE B-8 controllers by eliminating the electric braking features. The cars had been equipped with both air and hand brakes, so that the removal of the electric braking feature was more than balanced by a decrease in the width of the controller cylinder from 31 in. to 19 1/2 in., thus giving more vestibule space and reducing the load on the subsills. The change was made by taking out the stand wiring, finger-boards and cylinders. Then the cut-out switch box on the bottom was cut to measure 14 1/2 in. and the back of the controller shell was placed in a planer to be cut off to the desired size. The controller cover was also reduced in width by cutting out a piece between the reverse and braking handles, after which the side and back were planed to fit as shown in the drawing, without requiring any new castings whatever. In the transformed controller the running and reverse cylinders are in their original state, but owing to the change in the cut-out switch box, the last two blades to the right were removed to give the switch cut-out six knife blades instead of eight. Blades 1, 3, 4 and blades 5, 6 were then connected with jumpers. All wires were led to the right side and securely fastened with a piece of fiber.



G. E. B-8 controller braking cylinder.

Standard Car Connections (By H. Schlegel).—By standard car connections are meant connections such that a glance at any wire on a car will identify that wire whether it be tagged or not—in fact with recognized standard connections no tags or other identification marks are needed because a wire becomes identified by its position.

On small roads with uniform equipment the adoption of standard connections is a simple matter not likely to cause any confusion; on large systems representing absorbed roads of various equipments and methods, many obstacles are to be overcome. In any case if all devices—heaters, compressors, governors, headlights, car lights, switches, breakers, starting coils, arc-light resistances, air tanks, sand riggings, brake riggings, car cables, etc., are located according to drawing, the task of running wires in standard paths is much simplified. Where such standard location of devices is not observed, the task is more difficult, but satisfactory results can still be obtained, as far as the wires themselves are concerned, by running the wires in certain fixed relations to each other. To illustrate the advantages of being able to identify active wires, wheresoever they may be exposed, consider the proposition of standard motor circuit connections.

The first step toward standardization is an agreement as to the No. 1 end of the car. On a single-end car this is naturally the operating end and no further fixing condition is needed. Ordinarily, on double-end cars the No. 1 end is arbitrarily taken as the fuse box, register, resistance or wall-wire end; but on modern cars where these devices are likely to be duplicated such a rule is useless, for the "fuse box end" means nothing if there is one on both ends. Probably as good a plan as any is to take the cash register end, as it covers the possibility of two registers. If the registers are installed first, the electrical equipment must be installed accordingly and *vice versa*. In general, change the one that costs the least to change. An incidental advantage of having a fixed, recognized No. 1 end is that a motorman can readily tell the number of a faulty motor and avoid the hit-and-miss method of cutting it out.

Motors of different makes and even types of motors of the same make may rotate in opposite directions for apparently the same connections owing to the relations in which their field coils are connected. For example, the GE-57 and 67 motors rotate in opposite directions, so do the Westinghouse 68 and 101. The motor internal connections should be such that when the terminals are brought out of the frame according to a standard rule, the same polarity of field and armature terminals will produce on all motors the same direction of rotation; otherwise the wiremen cannot tell how to connect the motors of the car wires so as to move the car as indicated by the controller reverse handle. When no rule is observed in bringing out the terminals, the final results are a loss of time in connecting the motors, especially on a four-motor car, delay in locating the affected part in times of trouble and confusion in reconnecting after replacing a controller, motor or equipped truck.

Where the kinds of motors in use are too numerous to make the changes necessary to have all rotate in the same direction for given connections, the motor leads can be brought out according to rule; then the motors will be recognized as divided into two classes—those that rotate clockwise and those that rotate counter-clockwise for given connections, facing the commutator end. Suppose that experiment shows the rotation of an armature to be clockwise for certain connections; for example, the long B.H. lead being made T or +, the short B.H. lead being connected to the top field terminal and the bottom field terminal being grounded. Having thus determined the field and armature polarity that produce clockwise rotation, the wiremen know how to connect the motor to turn, hence move the car, in a certain direction, because: (1) All No. 1 controller A wires and F wires are + and all AA and E wires are −. Then to make the armature rotate clockwise it is only necessary to make the left-hand B.H. or long lead A, the right-hand B.H. AA, the top field terminal F and the bottom field terminal E or G. With a standard observed rule for bringing the terminals out of the motor it is unnecessary for the wireman to look into the motor to identify the wires, for he knows that the long B.H. lead, say the one to be made A to secure clockwise rotation, comes out of the top bushing, the short one out of the next, the F field terminal out of the next and the bottom or E field terminal out of the bottom bushing.

Once the leads of both motors are brought out in absolutely the same manner, the next step is to select an invariable order for bringing them through the spreader that separates and supports the terminals where they issue from the bushings. This order is arbitrary to a certain extent, but should be suited to that observed in connecting the controller car wires to the junction boxes. Assuming the junction boxes to be in place on the car, suppose that the rule adopted for connecting the No. 1 controller wires to them is as follows: facing the junction box the order of connecting controller car wires to it, counting from the right is A, AA, F, E, G. Irrespective of the position or angle in which the junction box is supported, the wireman then knows that when facing it single A lies to the right and G to the left, the other wires lying in regular order between them. If the order of bringing the motor terminals through the spreader, facing the spreader, be made just the reverse of this, the spreader wires can be brought to the junction box in the same order as they leave the spreader and car wires and motor wires of the same name thereby connected together, because since the spreader and junction box face each other what is to the right when facing one will be to the left when facing the other. When a wireman is ready to connect the motors after the trucks are run under the car, he knows that facing the junction box the single A is to the right, and that facing the spreader, the single A is to the left, G being at the opposite end in both cases. Furthermore, he knows when facing the commutator end which armature·terminal and which field terminal must be made + to have the armature rotate clockwise. As the top of the armature moves in the direction opposite to that in which the car moves, owing to the gearing between the armature and axle, it is an easy matter to tell in which direction the armature should rotate.

If the car is to move to the right, then, facing the commutator end, with the motor occupying relatively the same position that it will have on the car, the top of the armature must move to the left, which means that the armature must turn counter-clockwise. If the car is to move to the left, then the top of the armature must move to the right and the armature must turn clockwise. Knowing the rotation for given connections, and knowing that all motor connections and controller-junction box connections are the same, a wireman can connect a motor up right the first time irrespective of its position on the car.

Suppose that on connecting up a car in the accepted standard manner one of the motors turns in the wrong direction. If ringing out the connections of the No. 1 controller to the junction boxes shows them to be right (the armature connections are always reversed in the No. 2 controller) and inspection shows the motor terminals are brought out of the bushings, through the spreader to the junction box in regular order, then the reversed rotation must be due to an irregularity in the controller or in the motor itself. If ringing out proves the controller internal connections correct, then the probabilities are that the motor has a so-called "left-hand armature."

In actual service on a road employing four-motor equipments of 57, 67, 80, 52, 58, 1000 and 800 (G. E.) and 56, 12*A*, 68, 49 and 101 (Westinghouse), the 57, 1000 and 101 motors were in one similarly rotating class and the rotation of other motors was opposite. The standard features on all were those indicated. The instructions given the wiremen were: "On 57, 1000 and 101 equipments run motor wires straight from spreader to junction box on motors 1 and 3. Cross armatures on motors 2 and 4. On all other equipments cross armature terminals on motors 1 and 3 and run all wires straight on motors 2 and 4."

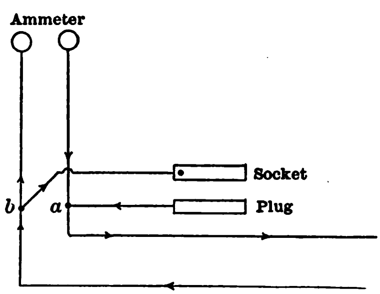
Standard starting coil connections greatly lessen the probability of getting the resistance wires confused and minimize the time of connecting or reconnecting after disconnecting for testing or equipment changes.

Standard disposal of the frames composing the starting coil may have to be limited to placing the No. 1 frame always toward the No. 1 end of the car, this limitation being imposed by the fact that the manner of placing the frames must be suited to the available room under the car—a very variable factor. However, if the R_1 end of the No. 1 frame is so placed, the No. 2 frame being placed next, and so on, and the resistance wires out of the cable are brought through a spreader in the same order, the resistance wires will connect consecutively, and any confusion in the connection will be readily noticed.

The ideal starting coil connection is realized when the frames have their terminals on one side and the available floor space is such that the frames can be installed in a row. When the frames must be installed in a row along the short center line of the car, a very desirable way to install them, the No. 1 frame can be so placed that it is to the right or left of a person standing in the center of the car and facing the No. 1 end.

The preceding are merely suggestions adapted from actual experience in standardizing connections on a system employing ten kinds of motor equipments. The method to be pursued and the extent to which the standardizing idea can be carried depends on the complications existing in particular cases. In all cases, however, time, labor and material can be saved by the adoption of standard connections, the positions of the wires being fixed with the guiding object of keeping the most positive wires at one extreme position and the most negative at the other. Such connections rigidly enforced have proved an efficient check on the connections of fields and armatures from the winding room and on repair controllers. They have decreased air governor troubles incident to confusion of the governor wires, and have emphasized the desirability of having apparatus installed according to a layout adapted to the greatest possible percentage of the total number of cars maintained.

Practical Shunting Kink (H. Schlegel).—Having occasion to run watt-hour absorption tests on a 200-h.p. railway motor equipment, with voltmeter and ammeter, and the largest capacity of ammeter available



being a 400 amp. Weston instrument, it was necessary to increase temporarily the current indicating capacity by means of an improvised shunt. The resistance of the meter was only 0.00063 ohm, so that the cross-section of conductor required to by-path the meter alone would have been unwieldy and the adjustment impracticable with the facilities at hand. The successful plan adopted was as follows: Two pieces of No. 4 B. & S. flexible cable, each 4 ft. long, were tapped at their middle points as indicated in the diagram. Both ends of the tapped cables were trimmed and tinned; one end of each cable was connected to the ammeter. To the free end of the *a* cable was soldered 8 in. of $\frac{3}{4}$-in. brass rod, which was to serve as a plug; to the free end of the *b* cable, was soldered 8 in. of $\frac{3}{4}$-in. seamless brass tubing to serve as a socket. The plug and socket telescoped each other snugly, but both were thoroughly cleaned and tinned to insure a perfect contact at the sliding joint. The resulting fit was so good as to require a small hole to be drilled in the tube before the plug could be inserted against the resulting air cushion. As the 4 ft. of cable leading to the meter was just electrically balanced by the 4 ft. of cable in the shunt, the duty of the sliding joint in the shunt was to admit an adjustment that would just balance the meter resistance and to serve as a switch for opening and closing the shunt circuit to note its effect on the ammeter reading.

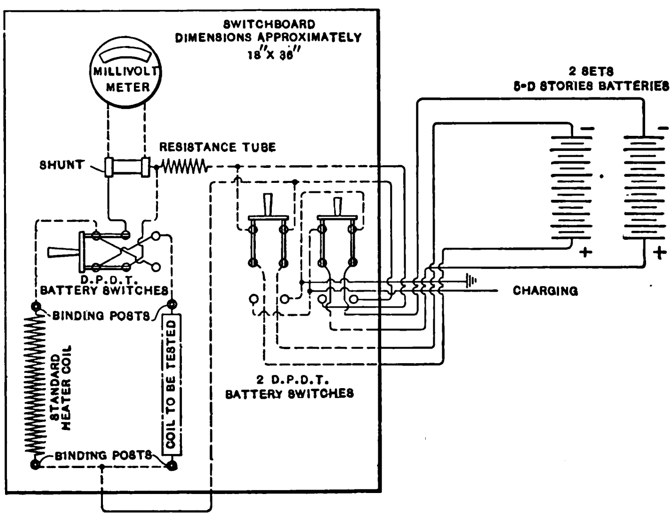
The adjustment was tedious, as it was made on a railway circuit of very changeable voltage; it was effected as follows: The plug was run into the socket as far as it would go; the current through shunt and meter was then regulated until the meter reading was approximately 150 amp.; on withdrawing the plug, the meter reading increased to approximately 300 amp. The final adjustment consisted in so proportioning the amount of engagement between the plug and socket, that withdrawing the plug would double the meter reading and inserting the plug would halve the reading; this condition secured, the indicating capacity of the instrument would be doubled and the total current flowing at any time would be twice the meter reading. After considerable trial and patience, three readings were obtained—one on withdrawing, one on reinserting, and the third on again withdrawing the plug from the socket—this set of three readings being taken to insure that the current did not change in value during the final adjustment. A higher reading ammeter, two ammeters in parallel or a wattmeter would have saved much trouble, but none of these was available within the time limit prescribed.

The adjustment was checked with a high-reading meter after the test had been run and found to be sufficiently close for the purpose in hand. It was not absolutely necessary that the multiplying power of the shunt should be a whole number 2, but by taking a little more trouble to have the multiplier a whole number, much calculation labor was saved in the subsequent handling of the 1200 current readings taken. It may be remarked that two ammeters in parallel will not indicate current equal to the sum of their capacities unless the resistances of the meters have the inverse ratio of their capacities; of course they can be made to share current in any desired ratio by manipulation of their binding posts, but with heavy currents flowing more than a short while, this is not recommended.

XII

HEATERS, LIGHTING, SIGNS AND SIGNALS

Brooklyn Heater Testing.—Heater tests on the Brooklyn Rapid Transit System are of two kinds, those of energy consumption, which are made by the heater maintenance specialists directly on the cars, as described elsewhere, and those which are made in the shops as now described. The purpose of the shop tests is to make certain that individual coils of heaters sent in for repairs are of the proper resistance. The method of tests is to use a modified Wheatstone bridge on which the individual coil is balanced against the resistance of the master coil of a given type

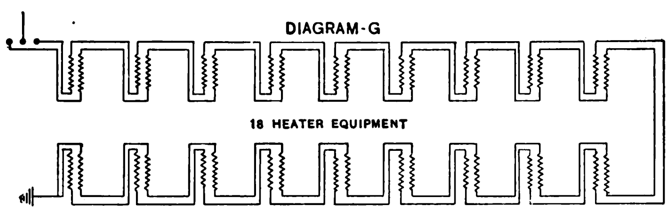


Wiring of board for testing heater coils, Brooklyn.

of heater. The necessity for tests of this kind is indicated by the fact that there are twenty-nine types of Consolidated and ten types of Gold heater coils on the Brooklyn Rapid Transit System. The master coils of each type are kept on a board in the local storeroom of the department of electrical repairs at the Fifty-second Street shop, whence they are taken out as required for comparisons with new coils for size of wire, number of turns, resistance, etc. If the coil is of unknown type it can readily be identified by means of a calibration curve which shows what the resistances should be for different values of current.

The Brooklyn heater-testing equipment, as illustrated in the accompanying drawing, consists of an 18-in. × 36-in. board on which a millivoltmeter and two double-pole, double-throw battery switches and a third double-throw, double-pole switch are mounted. The battery switches are thrown one way for charging and the opposite way for discharging, while the third switch is so arranged that when thrown in one direction the current goes through the master coil to give a reading on the meter and when thrown in the opposite direction the current is sent through the coil under test. If the resistance of the coil is correct, the two readings must be practically the same. This testing outfit is also used for magnet coils and the like.

Specializing Electric Heater Maintenance in Brooklyn.—The mechanical department of the Brooklyn Rapid Transit System inaugurated in 1910 the specialized maintenance of electric heaters. Formerly the regular maintenance force was employed for this work, but it was found that some of the men did not have enough knowledge of the construction and the circuit arrangements of the heaters to do the most effective work. This practice has been changed by employing heater experts who go from depot to depot in turn until all heaters have been examined and placed in first-class condition. To make accurate investigations, they



Coils of Consolidated 217 R. J. and Gold two-coil column heaters.

CONSOLIDATED 217 R. J. HEATER

Cross-seat Heater with Junction Box 23 in. long,
Double Coil, Single Spindle,
18 Heaters per Car

Diagram G

Original current consumption, 4–8–12 amp. Allowable amount on account of aging, 4.2 to 5 amp. on first point and 8 to 9 amp. on second point.

GOLD TWO-COIL COLUMN HEATER

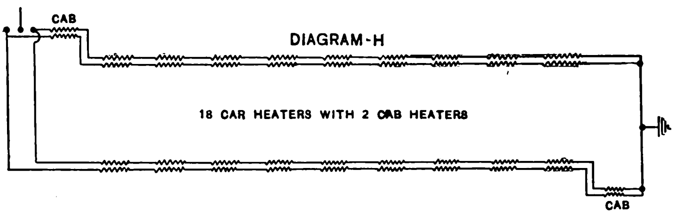
Cross-seat Heater, Two Coils
18 Heaters per Car.

Diagram G

Original current consumption, 4–7–11 amp. Allowable amount, 3 to 4 amp. on first point and 6 to 7 amp. on second point.

use a low-reading ammeter and voltmeter. The ammeter is employed to check up the current consumption at the different switching points. If this consumption varies widely from the standard the coils and their connections are examined. The voltmeter is used to get the drop of potential across the heaters and to ground; also to trace the connections when determining if wrong coils are in the heater or if right coils have been misplaced. The men are furnished with a descriptive schedule of the various types of heaters on the system with accompanying wiring diagrams so that the heaters can be readily identified and be correctly connected. Two typical descriptions are presented.

It will be noted from the instructions that an allowance is made for the increased current consumption of heaters on account of their aging in service. In some instances, however, the original ratings were too high, so that no excess current ratings are now required.



Wiring scheme of Consolidated 146 X heater, Brooklyn.

Panel Heaters, Two Spindles, Punched Steel Front.
18 Car Heaters, with 2 Cab Heaters, 118 W. and 146 G.

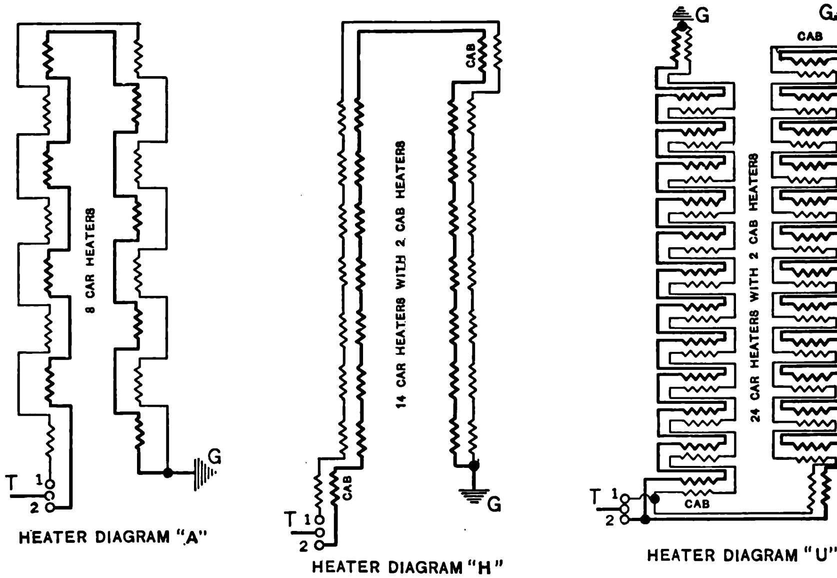
Diagram H

Original current consumption, 6–12–18 amp. Allowable amount on account of aging, 6.5 to 7 amp. on first point and 13 to 14 amps. on second point.

To minimize errors in orders from the shops for heater supplies the mechanical department has prepared a series of numbered photographs of the several parts of each type of electric heater in service. A bound set of these photographs is furnished to each shop and storeroom. The photographs were made direct from disassembled heaters in the shops of the Brooklyn Rapid Transit System.

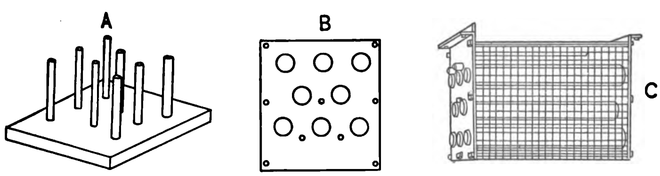
The heater wiring diagrams are used in connection with the photographic handbook. Reference letters are used in this book to indicate the corresponding wiring diagram in the shop data sheets. The shopman therefore has every possible aid in identifying the exact style of the heater and in determining exactly what should be done to repair and wire it properly. Wiring diagrams are presented of the twenty styles shown in the present binder.

A Stand for Headlight Resistance Coils.—The stand shown in the accompanying sketches will be found very helpful in repairing the Crouse-Hinds headlight resistance coils, when it is necessary to repair broken wire or to replace broken tubes. Any one accustomed to repairing this resistance will find that after either end plate is removed the tubes will



Three heater diagrams, Brooklyn.

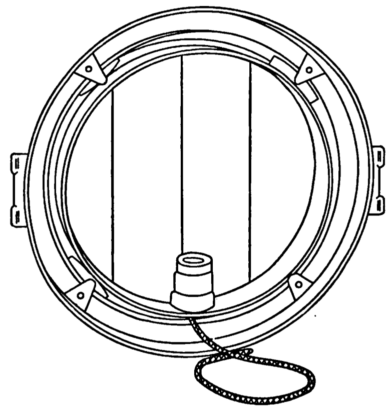
fall together and it is very difficult to replace them in their proper places. The base of this stand is an inch board 8 in.×8 in. in size, with 1/2-in. holes laid off to correspond to the holes in the end plate "B." One-half inch pins are made 4 in. long, and these are driven into the holes in the baseboard. When the resistance is to be taken apart the center rod

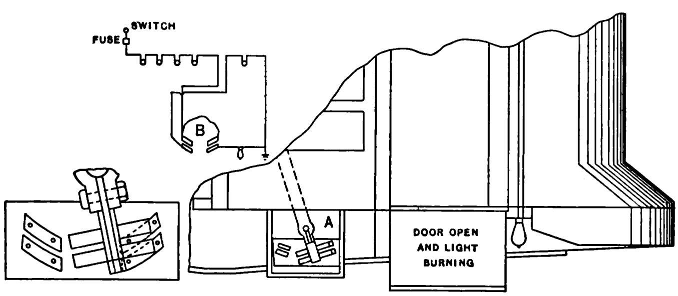


Repair stand for headlight resistance coils.

"C" is reversed so the nut will be on the other end. The other rods are taken out and the resistance placed on the stand, then the nut on the center rod is removed. It will be found that the stand will hold the tubes apart in their respective positions, whereupon the repairs can be easily made. By making two of the stands, the resistance can be inverted and the other end plate also removed.

Assembling Glass in Headlight Doors.—When the door of the headlight is bent or out of shape, it is quite difficult to adjust the several pieces of glass into place. The glass is sent from the factory cut circular in four pieces. It is a long and tedious job to put the gasket around the glass and place it into the frame straight. To avoid this, cut a pasteboard templet the exact shape of the frame which is to receive the glass. Lay the pasteboard templet under the glass and cut around it with a glass cutter. Tap the glass where the marks have been made with the end of the glass cutter. Break the glass away to leave a piece the same shape as the templet. Divide the glass into four equal parts and cut straight parallel lines, by the aid of a straight-edge. When this has been done, take a rubber gasket and place it around the edge of the glass, first having put a little shellac on the ends of the gasket, to hold it together. Put the glass into the frame of the headlight door and fasten securely with the four little clamps, as shown in the cut. Tap the glass where the four parallel lines have been cut, so the glass will break at these places, thus allowing room for expansion when the glass becomes hot.


Assembling headlight door glass.



Circuit for step-lighting arrangement, Saginaw.

Step-lighting Device for Saginaw Prepayment Cars.—In 1912, the Saginaw-Bay City (Mich.) Railway equipped its prepayment cars with an automatic step-lighting arrangement invented by L. A. Gaw, master mechanic. The purpose of this illumination is to enable alighting passengers to see the condition of the pavement below the step, especially at street crossings without arc lights. This company's double-end prepayment cars have the usual incandescent lamp beneath the roof on the entrance side but none on the exit side. Under the new arrangement the same lever with which the motorman opens the exit door serves to close a bottom contact, thereby throwing off the roof lamp and throwing in a lamp placed alongside the exit step, as illustrated in the accompanying drawing. The step lamp is cut out of the circuit and the other lamp is cut into the circuit when the exit door is closed.

Method Used for Lighting Markers Electrically.—An ingenious scheme for electrically lighting the markers on the Terre Haute, Indianapolis & Eastern Traction Company's interurban cars has been devised by G. R. Denehie, master mechanic. Heretofore the markers were supplied continuously with current from twelve storage batteries which were in series with the lamps; now the batteries furnish the source of energy only when the trolley wheel is off the wire or the current is off the line. The original method of furnishing the current from the batteries was unsatisfactory owing to the number of circuits required and the reduced candle-power in the high-voltage lamps. The revised wiring diagram is shown and consists of a 7-volt storage battery in series with four 110-volt, 16-c.p. lamps. A relay in the light circuit opens an auxiliary circuit, which consists of four 7-volt, 4-c.p. lamps connected in parallel. This auxiliary light circuit operates in series with the storage battery when the trolley current is off. One 110-volt lamp and one 7-volt lamp are installed in each marker.

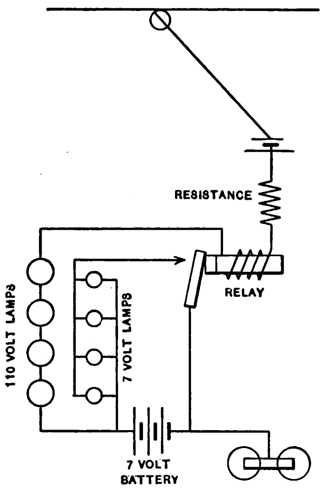
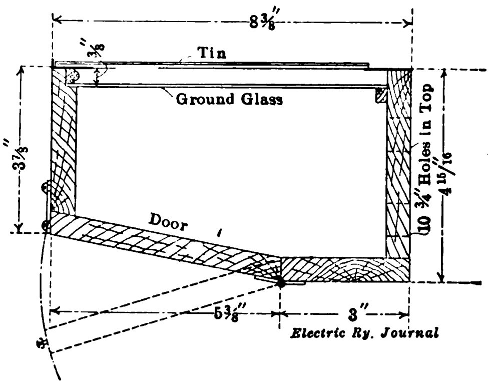


Diagram of circuit for lighting markers electrically.

Novel Route Signs on the Peoria (Ill.) Railway.—The Peoria Railway Company installed in the year 1913 route signs of a novel design on the city cars in Peoria, Ill. The sign is a triangular prism built of light structural angles and 18-gage sheet metal, the base being shaped to fit the contour of the car roof. Two signs are mounted at right-hand diagonal corners of each car, and the right-angle faces of the signs are set parallel to the front and sides of the car. These two faces are 17 in. × 18 in. in size and take a 12-in. initial letter and 3-in. letters in the printed destination. All letters are perforated with 5/16-in. holes which permit reflected light from a single 16-c.p. lamp installed between the letters on the sign front to illuminate them at night. The interior of the sign is painted white to intensify the indirect letter illumination, making it possible to read the sign easily at 500 ft. during either day or night. The lamps in the two signs are in series with the lamps in the car and are controlled by the same switches.

The lettered panels are interchangeable as guides in the sign frame permit them to be removed and replaced by any other destination sign, in case it becomes necessary to change a car's routing. A complete equipment of sign panels is kept at each carhouse, and each crew is required to see that the correct indications are in place before the car is taken for a regular run.

Detroit United Train Number Sign.—A novel illuminated train number sign for the interurban cars of the Detroit United Railway Company, Detroit, Mich., was designed by its mechanical department in 1912. The novel features include illuminated numerals, which may be easily changed to any series of three numbers in a cheap yet substantially constructed sign box, and the method of mounting this box in the car window. Essentially the sign consists of a box



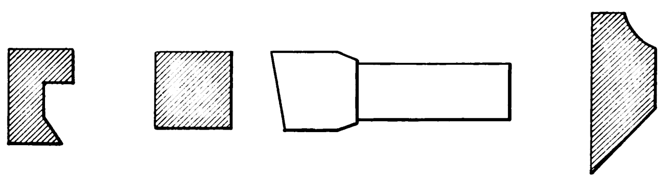
Construction of sign box, Detroit United Railway.

5 in. wide by 8 1/2 in. deep by 23 3/4 in. long, constructed of 5/8-in. poplar. The back of the sign, which tapers from 5 in. at the top to 3 7/8 in. at the bottom, is provided with a 5 3/8-in. door. The front is covered with 18-gage tin, through which three openings, 6 1/2 in. by 6 3/8 in. in size, have been cut. Each opening is provided with guides to take the number slides. Just back of this tin frame, and separated from it by an air space of 3/8 in., is a ground-glass partition which incloses the lamp compartment and serves as the illuminated background for the train numbers when in position in the metal front. The interior of the box is painted white, and a 16-c.p. lamp mounted near the center of the top supplies sign illumination. Properly to distribute the light to the three numbers, a piece of close-meshed wire screen slightly larger than the vertical cross-section of the lamp is attached to the top of the sign between the lamp and the number plates.

In order to prevent the numbers from being placed in the sign incorrectly a rivet is set in one metal guide of each pair 2 in. from the bottom. The numbered slide, which is similar to an ordinary metal stencil, is notched on one side up 2 in. from the bottom and is 5/32 in. wide. This simple arrangement makes it impossible to insert numbers in the sign box in the reverse position. Ventilation is provided by ten 3/4-in. holes bored through the top of the box.

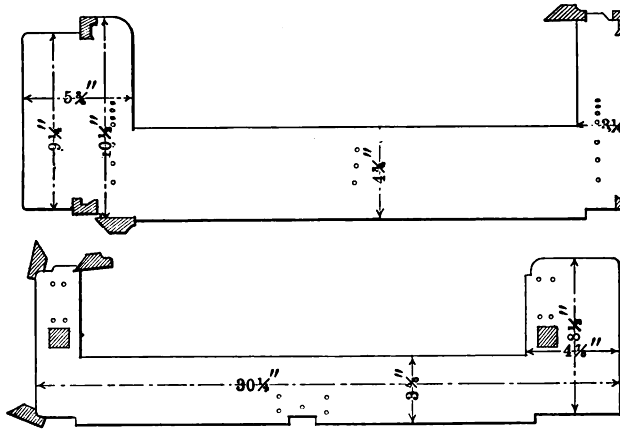
When mounted in the cars these sign boxes are placed in the upper sash to the left of the front vestibule, being hinged to the sash rail at the bottom and hooked to the upper rail. This arrangement permits the sign to be unhooked and dropped so that the numbers may be changed as required by the different runs. The sign lamps receive their energy from the car-lighting circuit, being in series with the lamps in the car. Each box is provided with a receptacle and the front vestibule has a cord plug so that electrical connection may readily be made. A case containing a series of ten numbers, three of each kind, letters "W" and "X" for work train and extra, and one blank slide, has been placed conveniently in the motorman's cab of each car.

Manufacturing Sign Boxes and Signs (By P. V. See).—Small car shops seldom have the opportunity to manufacture any article in such large quantities that the refinements of tools and machinery that are secured in factories can be adopted. At the Jersey City shops of the

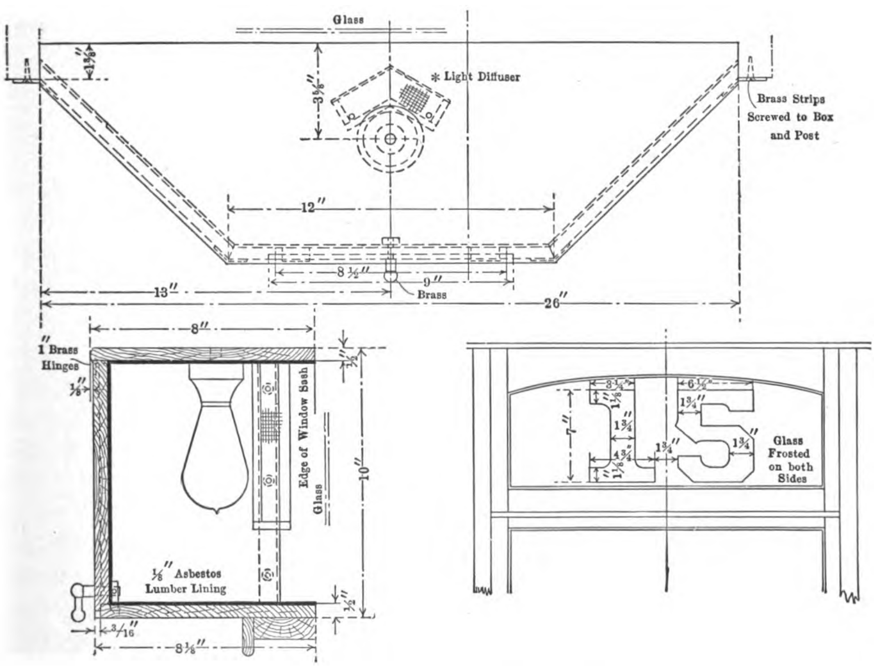


Figs. 1, 2 and 3.—Dies for sign boxes and signs, Hudson and Manhattan Railroad.

Hudson & Manhattan Railroad, however, the cost of making 400 sign holders and 2000 signs for the same was greatly reduced lately by the use of some very cheap dies. An old sheet-metal geared hand punch was used for the work. The dies were made from scrap tool steel left over from lathe tools which had become too short to use in the wheel lathe. This steel was annealed and rough-forged and then shaped and hand-filed. The edges of the die shown in Fig. 1 were so designed that the same die would work in various places on the box, so that it was used six times on each box. The die shown in Fig. 2, which was used twice on each frame, cut out three sides of a square and bent the metal at the same stroke. The three edges of the die shown in Fig. 3 were so designed that the die was used in ten places on each box. The applications of the dies are shown in Figs. 4 and 5. When the proper stops were placed on the punch the most ignorant laborer could be used to do the work. All the boxes were found to set together perfectly, and the dies were still in good shape after the job was finished.



FIGS. 4 and 5.—Application of dies for signs and sign boxes, Hudson and Manhattan Railroad.



Asbestos-lined box for route number sign, United Railways & Electric Co., Baltimore.

Route Number Signs at Baltimore.—In addition to roller type destination signs in the sides and ends of the monitor deck, the United Railways & Electric Company began to install during 1913 route number signs which are placed over the middle sash of the vestibule. The use of a route number is a natural evolution from the Baltimore system of numbering cars or given routes by hundreds. Thus a car numbered 401 has sign number 4. The route number is 7 in. high and is painted on ground glass. It is illuminated by means of a lamp which is placed in a wooden box lined with asbestos lumber. A most effective distribution of light is obtained by using the diffuser of fine wire which is shown in the drawing of the sign box.

Painting Illumination Destination Signs at Nashville, Tenn.—The largest single item in the cost of maintaining illuminated car destination signs is found in keeping the lettered panels in legible condition. The usual custom is to retouch the letters by hand, but when it becomes necessary to renew a section of canvas to replace the names of the destinations by hand, painting is quite expensive. To reduce this cost of renewal to a minimum, G. W. Swint, master mechanic of the Nashville Railway & Light Company, Nashville, Tenn., has devised a scheme whereby a thirty-six name sign may be replaced with a new one at a cost of $1.50 for material and labor. Instead of doing the work by hand it is printed on the canvas by wooden blocks of the hollow-letter type. The blocks were made in the company's shops, and as many were prepared as there were destinations. The cost of carving the letters in the white pine blocks was comparatively low, and the useful life is, of course, unlimited.

The complete printing outfit comprises, in addition to the hollow-letter blocks, a section of plate glass by means of which a composition of printer's ink is evenly applied to an ordinary rubber roller, a padded table with clamps to hold the canvas firmly in position and an old armature core which is used to press the wooden block type against the cloth.

The ink is applied to the block by passing the rubber roller across it, and the block is then laid upon the white canvas, the armature core being rolled once or twice across it.

The quality of printing ink applied to the hollow-lettered panels and the weight of the old armature core cause the ink to penetrate the canvas, giving a longer life than when applied by hand. The names making up a complete set of destinations are printed in series of five to a canvas panel. These panels are sewed together in one long strip for the car signs. In case only a portion of this lettered canvas becomes badly soiled, it may be ripped from the rest of the roll and a new panel supplied. The work of printing these signs is so simple that an expert is not required nor even a man specially detailed to do the work. Two men familiar with the operation, however, easily make eight five-name panels in an hour.

Conductor's Push-button Signal.—In all cases, the Denver & Interurban Railway puts a push-button stop signal for the use of the conductor in the jamb of the door in the rear end of the car. This feature has been found a great convenience and time-saver both in ordinary operation and in emergencies.

XIII

WELDING METHODS, SHOP TOOLS, STORAGE, ETC.

Oxy-acetylene Welding at Hartford.—The oxy-acetylene welding system is used at the Hartford shops of the Connecticut Company for repairing pinion-end breakage of AA-4 compressor armature shafts. The shaft is cut off for some distance beyond the break and then bored to a depth of 1/2 in. to 3/4 in. for alignment with the new metal. The two pieces are then welded and turned down to the proper diameter.

Electric Welding in Pittsburgh.—Since Sept. 18, 1911, the Pittsburgh Railways Company has been using an electric welding outfit at its Homewood shops for the successful repair and reinforcement of all classes of metal equipment except those made of gray iron castings. During its first week this welding system saved about $237 and every bit of material, the flux excepted, was taken from the scrap pile.

Current for welding is furnished by an old GE booster set consisting of a 30-h.p. shunt-wound motor and a 60-volt, 300-amp. generator. Nevertheless, the actual output of the generator can be varied from 300 amp. to 700 amp. at 80 volts to 110 volts, according to the conditions desired. There is enough reactance in the generator to take care of sudden surges when the welding arc is broken. The shunt field of the booster is directly excited from the trolley circuit through a resistance connected in series with it across the line instead of being shunted around the series winding of the generator. The switch controlling this separately excited shunt-field circuit is locked to prevent anyone from breaking this circuit when the set is running free. The grid resistances, which are inserted in the series field in series with the armature, can be varied from 0.02 ohm to 0.045 ohm, depending upon the amperage desired.

The welding flux consists of 17 parts borax, 1 1/2 parts brown oxide of iron and 1 1/2 parts red oxide of iron. The electrodes are usually of carbon, but cold rolled steel is used for such work as welding sheet steel on a gear case, the melting of the electrode itself furnishing the required new metal.

The economies of this method of welding may be appreciated from the following typical cases, which give the price of certain parts new, their value as scrap and the cost of rehabilitating them for service. In each case 15 per cent. is added to the shop cost to allow for overhead shop charges. Welding labor is figured at 30 cents an hour and electrical energy at 1/2 cent per kilowatt-hour.

Article	New	Scrap value	Labor, welding	Carbons and flux	Power	Overhead charges	Saving
Bemis side frame.........	$26.25	$2.18	$0.88	$0.37	$1.92	$0.48	$20.42
Lord Baltimore side frame.	28.00	1.83	0.33	0.05	0.72	0.17	24.90
McGuire Columbian side frame.	35.00	1.83	0.33	0.05	0.72	0.17	31.90
Westinghouse No. 56 motor frame.	......	.....	0.99	0.17	2.16	0.50	......
Westinghouse No. 62 motor gear case lugs.	......	......	0.22	0.21	0.48	0.14	......

Electric Arc Welding.—The low cost and simplicity of welding by means of the electric arc make this process, under some circumstances, the most satisfactory method of repairing defects in steel castings, according to B. M. Bowers in a paper read in 1912 before the Associated Foundry Foremen at Philadelphia. The writer states that the efficiency of the ordinary electric arc weld is generally about 60 per cent. of the original strength of the material, probably on account of oxidation, although greater efficiencies have been attained. The apparatus usually consists of a suitable tank filled with salt water and containing two steel plates, one of which is connected to the negative side of a direct-current line ranging in voltage from 110 to 550. From the other plate the cable is run to one end of a carbon electrode consisting of a piece of 3/4-in. wrought-iron pipe 18 in. long and threaded at the other end to carry a 3/4-in. socket. In this socket a pair of steel clamps holds an arc carbon 1 in. in diameter and 6 in. long, tapering to a point. A wooden handle is placed over the pipe at the center to protect the operator's hand. The piece to be welded is connected to the positive side of the line, and by adjusting the steel plates submerged in the tank a current of any desired amperage can be obtained.

The intense heat and light from the arc necessitate the operator's wearing a mask over his head with colored glass eye-holes, and his hands should be protected by gauntlet gloves.

By bringing the carbon electrode in contact with the metal to be welded and then withdrawing it an arc is produced by which the metal can either be fused, molded or melted away entirely, as desired, the heat varying inversely as the length of the arc. While the arc is drawn, welding material is fed in slowly. This consists, for steel castings, of a soft steel wire about 5/16 in. in diameter and containing about 0.10 per cent. carbon. Vigorous hammering should accompany each weld.

For burning off scales, fins, gates or risers a current of about 500 amp. should be used, and by means of a smaller current blow-holes, sand spots, checks and cracks can be filled or lugs can be welded onto the casting.

Castings should be heated before welding in a forge and welded while red hot, but reheating of the castings after welding is detrimental. The arc should be as long as possible in order to reduce excessive oxidation produced by the intense heat. At times a flux of melted and powdered borax is essential as it prevents oxidation by protecting the metal from the air. In welding brass or other metals with a low fusing point the casting must be supported in such a manner that the shape will be retained. The arc should also be applied at a low voltage and only for very short periods.

Electric Arc Welding by the Third Avenue Railway, New York.—As an essential conditon to good work, the Third Avenue Railway has the principal welding outfits and appurtenances where the welders can labor under the best conditions. The welding room is part of a high truck-shop basement, and it is bounded by the whitewashed brick piers which were originally erected to carry cable machinery. This room has a large opening at the top for air and natural light, but two fans and several clusters of lamps are also installed. The welding section really comprises two rooms, one in which the work is done and the other, a side passage, where the resistances and switchboards are installed.

As energy is taken direct from the 550–600-volt substation bus, enough resistance was provided to reduce the voltage at the arc to approximately 50–75 volts. These resistances are obsolete car grids which are suspended from the ceiling of the side passage. Three switchboards are installed as follows: The first supplies currents of 200, 250 and 350 amp. for such work as welding broken motor shell lugs, broken truck frames, etc.; the second board furnishes currents of 75, 125, 150 and 200 amp. for welding gear cases, filling in worn axles, dowel-pin holes, etc., and the third switchboard gives currents of 170, 220 and 270 amp. The middle board has a connecting switch so that any current within its range can be transmitted to a board on the truck-shop floor where work is done directly on the trucks. This board is also fitted with a recording watt-hour meter in order to record the energy consumed for any particular job, should such data be wanted. This watt-hour meter can also be readily transferred to the other boards if desired. The total energy supplied for all welding work is recorded by means of an integrating wattmeter in the feeder circuit, and a regular charge is made at the rate of 1 cent per kilowatt-hour to each job for the energy used.

Current for each set is taken through two circuit-breakers, one on each leg of the line, the negative side passing directly through a flexible cable to the burner or torch, while the positive is applied to the work after being led through the proper combination of resistances. All work is placed on an insulated table, and the men stand on fiber mats. The operator's torch consists of a pipe 1/2 in. in diameter and about 2 ft. long. The outer end of this torch carries a carbon pencil while the inner end is attached to the negative lead. The back of the pipe is well insulated to permit its use as a handle, and a round fiber shield is also applied at the middle of the pipe to protect the hand of the operator from the arc. Each welder is guarded about the head and eyes by a hood made of canvas and framed with light tin in the form of a head band. The hood carries an eyepiece of red, green or blue glass. A canvas shield also separates the two operators.

The chief supplies necessary for this work are the carbon pencils, welding powder and additional metal. The carbon is 3/8 in. in diameter and 6 in. long, costs about 3 cents and will last a full working day. Instead of a flux, the company simply uses for cast-iron parts a white welding powder which costs but 8 cents per lb. Pure Norway iron free from carbon is used for any work which necessitates finishing—namely, boring, turning, planing, drilling, etc.

Costs and Savings.—The following data, which are taken from the weekly reports of the electrical foreman to J. S. McWhirter, superintendent of equipment, will convey an adequate conception of the importance of electric welding from the standpoints of costs (neglecting the small overhead charges) and savings.

For the week ended Jan. 25, 1913, the record was as shown in Table I.

TABLE I.—RECORD OF WELDING DONE DURING WEEK ENDED JAN. 25, 1913

Work done	Unit cost new	Total cost new
Welding axle lugs on seven Westinghouse-56 motors (half shell without fittings).	$50.00	$350.00
Welding one K-8 broken controller frame	9.00	9.00
Welding five pony axles around button	7.50	37.50
Welding Westinghouse-310 armature shafts, one broken and two with worn keyway and pinion fit (shaft).	8.60	26.40
Total	....	$422.90
Cost of labor	$36.50	
Cost of material	1.50	
Cost of current at 1 cent per kw.-hr	30.00	
Total	....	68.00
Saving	....	$354.90

In addition to the work tabulated, dowel holes were refilled in thirty-seven armature caps, seventeen axle caps and four motor shells. The exact saving in the case of dowel-pin holes cannot be given, but it is estimated that a badly worn dowel hole in a motor shell adds $50 a year to the maintenance cost of an armature and $25 a year to that of an axle cap. The man who welded the motor shells also repaired the controller frame and eleven axle caps and this work required ten out of the sixty hours which constitute a week's work in the shops. His wages for the week were $18. Of the charge of $10 for electrical energy, $8 were due to repairs on the motors. Consequently the cost of repairing seven motor shells was $15 for labor and $8 for current, or about $3.25 per shell. This compares with $18 and $23.50 charged by outside contractors for similar jobs.

For the week ended Feb. 3, 1913, the record of the three operators was as shown in Table II.

TABLE II.—RECORD OF WELDING DONE DURING WEEK ENDED FEB. 3, 1913

First Man

Work done	Unit cost new	Total cost new
Welding seven motor shells (half shells)	$50.00	$350.00
Welding one axle	7.50	7.50
Total		$357.50
Cost of labor	$15.00	
Cost of material	1.00	
Cost of current	8.00	
Total		24.00
Saving		$333.50
Second Man		
Welding eleven axles	$7.50	$82.50
Welding one motor inspection cover	2.00	2.00
Total		$84.50
Cost of labor	$15.00	
Cost of material	1.00	
Cost of current	10.50	
Total		26.50
Saving		$58.00

Third Man

The work done by the third man was of widely miscellaneous character, but it was estimated that he produced a greater saving than the others, his jobs being as follows:

Filling dowel holes in fifty-three armature bearing shells.
Renewing nine Brill brakeshoe heads.
Filling eleven dowel holes in axle caps.
Welding one journal box.
Welding one Westinghouse-56 motor shell.
Filling dowel holes in six motor suspension angles.
Welding one controller frame.

The data presented are sufficient to demonstrate the low cost of electric welding, but it should be added that the welded equipment has proved good in service as well.

Motor Rejuvenation.—In addition to the foregoing work electric welding has been adapted to convert the No. 56 motor into practically an entirely new machine. The company has long been confronted by the problem of making its 220 GE-57 and 571 Westinghouse-56 motors as reliable and efficient as later equipment. These motors had been in constant service for from twelve to fifteen years, but after the purchase of interpole motors some three years ago they were retained chiefly as reserve equipment. The growing business of the company has made it desirable, however, to see what can be done to make this equipment economical for constant service. The GE-57 motor has received an entirely new box frame, as noted later, but the Westinghouse-56 has been welded from a split-frame to a box-frame motor.

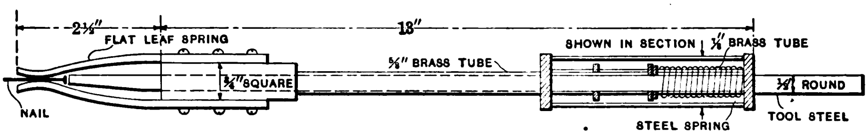
Had the No. 56 motors been continued in service with split frames it would have been necessary to rebore the frames for larger bearings, but this change would not have eliminated the faults of the original design. Electric welding, on the contrary, offered the opportunity of reinforcing the axle-bearing supports and other weak portions. The cost of welding the first frame, including new frame heads, gear cases, brush holders and other material required to make the motor operative, was $90; that of the second was $80, and in quantities the unit cost will be only $65.

In welding a No. 56 frame the first step is to place a clamp around the split frame and then apply the electric arc to cut off the old grease boxes and ends of the motor. Following this, the halves are bound permanently by two cast-steel rings—one of 1 1/4-in. thickness which is welded to the commutator end and one of 2 1/2-in. thickness which is welded to the pinion end. The rings are set off about 3/8 in., and owing to the irregular shape of the motor ends, the metal added may extend to a depth of 4 in. In addition, the weld is further reinforced by the frame-head bolts which pass clear through the ring, the intermediate metal and the shell. Two extra ribs are also welded in to strengthen the axle lugs. The final step is to weld the seam between the halves of the motor shell, but the seam weld is not relied upon to keep the motor intact, the real strength being in the rings and bolts. The welding rings are machined, of course, to take the frame heads.

The GE-57 shells were not rebored, but as this machine is a good motor electrically, it was decided to make a hybrid motor by placing all except the brush holders into a new box frame of a design very similar to the GE-210 motor. The cost of this change is about $185 per motor. This is not the price charged by the General Electric Company, but it is the approximate cost after allowance is made for the scrap value of the old material. It does not include any charge for labor because the work of placing the old armature, fields and pole pieces in the new frames is considered as part of maintenance expense that would have to be gone through with in any event.

Portable Heater at San Francisco.—Among the shop appliances of the United Railroads of San Francisco, is a portable electric heater used for small forging processes on truck parts or other bulky material which it would be inconvenient to heat in an ordinary oil furnace. The portable heater contains two tanks for the fuel, which is crude oil and distillate in equal portions. These are supplied under pressure to the burner, which is a blow-torch and receives its air from the compressed-air pipes which are carried about the shops.

Tool for Driving Nails in Inaccessible Positions.—Much trouble has been experienced in recabling the cars of the Topeka (Kan.) Railway

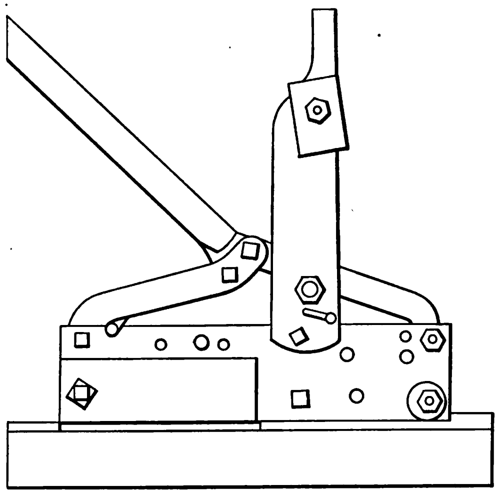


Tool for driving nails in inaccessible positions.

Company when the point of application is at a point inaccessible for nailing. In order to eliminate this difficulty S. S. French, master mechanic, has designed and manufactured a special tool for this purpose. In principle this device consists of a pair of leaf springs to hold the nail at the end of a tool-steel plunger. A hammer blow at the opposite end of this plunger drives the nail and is returned to the normal position by a steel spring. The device is simple, inexpensive and will pay for itself on a single car in time saved. The design details of this tool are shown in the sketch presented herewith.

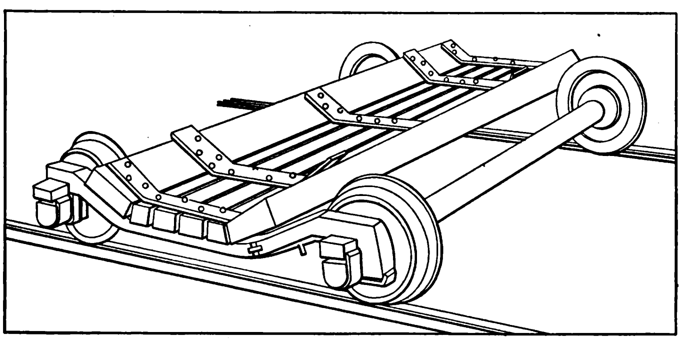
Home-made Metal Cutter.—The accompanying illustration shows a combination plate and bar cutter devised in the shops of the Charleston (S. C.) Gas, Railway & Electric Company. The plate-cutting portion comprises a toggle lever, one arm of which is a cast-steel cutter for handling any piece of cold iron up to and including 1/4-in. thickness and 3 1/2-in. breadth; the other arm is a soft-steel cutter for hot iron up to and including plates 3/4 in. by 4 1/2 in. The cast-steel cutter has a notch at one end to permit the cutting of round iron of 1/4-in., 5/8-in. and 1/2-in. diameter. The rounds cut in this manner need no chamfering to make them fit standard dies.

Bar-iron of 7/8-in. and 1-in. diameter is cut by means of a ratchet lever, parallel plates and dies in the following manner. The bar first is slipped through the corresponding hole bored in the plates, one of which is movable and the other stationary. The movable piece carries cast-steel cutting dies and is notched at the top to mesh with the ratchet lever. Hence when the latter is pulled over in either direction, the dies are made



Home-made metal cutter used to cut bar iron, Charleston.

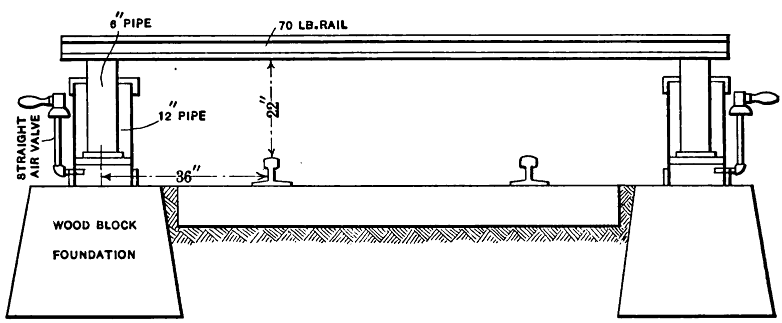
to bear against the bar and cut it. The base of this combination cutter consists of an old compromise rail-joint. The plates for the bar-cutter portion were made from abandoned brakebeams, while a discarded piece of trolley pole tubing answers as a sleeving to increase the leverage.



Wrecking truck, Pittsburgh.

Wrecking Truck Used in Pittsburgh.—For pulling in cars with broken wheels or axles the Pittsburgh Railways Company uses the low truck shown in the accompanying engraving. One of these trucks is hauled behind the wrecking car to the scene of the breakdown, and after the disabled truck is jacked up the cradle is run under it and the truck lowered so the wheels or motor rest on the heavy planks forming the platform of the cradle. The disabled car can then be run into the shop under its own power. The side frames of the cradle consist of 2-in.×2-in. steel bars bent down in the center and turned over at the ends to form the outside pedestal jaws. Straps 3/4 in.×2 in. are bolted to the underside of the frames and are bent down to form the inside pedestal jaws. They are continued across under the journal boxes and bolted to the ends of the outside pedestal jaws. The three planks forming the floor of the cradle are 3 in. thick, and are secured to the side frames with strap bolts. This truck is light enough to be lifted on or off the track by two men, and has been found to be very useful in handling serious breakdowns.

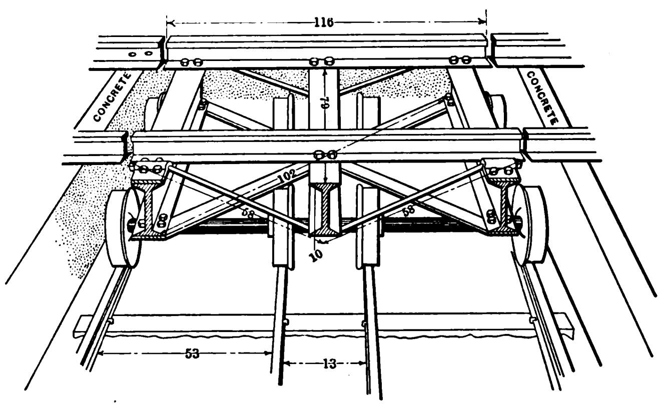
Home-made Car Hoist of the Choctaw Railway & Light Company.—At a total cost of approximately $40, M. Plunkett, master mechanic of the Choctaw Railway & Light Company, McAlester, Okla., has equipped his shop with an air hoist of sufficient capacity to lift one end of a 30-ton



Home-made car hoist used by the Choctaw Railway & Light Company at McAlester, Okla.

car. Essentially this hoist comprises two units, each located about 36 in. outside the rail on opposite sides of the track. Each unit is made up of a section of 12-in. pipe with a 6-in. pipe inside, the base of which is provided with a special cast piston head, and a piece of 70-lb. rail is extended between them to support the car body regardless of its width. This combination mounted on a substantial foundation takes the place of an ordinary hydraulic jack. The raising and lowering of the piston of 6-in. pipe is accomplished through an ordinary straight-air valve with the inlet just below the lowest position of the piston head. Air for these home-made hoists may be supplied either by connecting them to the air reservoirs on another car in the shop for which pipe and hose lines are supplied, or they may be attached to the air reservoir on the car body to be raised, thus causing the car to raise itself.

Cross Pit Truck Transfer Table.—One of the problems confronting the master mechanic of a small road where the amount of rolling stock does not warrant the installation of an overhead crane in the repair shop is the replacement of trucks at a minimum expense. This problem is particularly pertinent on interurban roads where it is necessary to jack up the heavy carbody to a sufficient height not only to clear the trucks but to allow the trucks to pass out under the pilot. In case it is not possible to do this, the pilot and possibly the draft rigging must be removed, a task which entails considerable expense. In solving this particular problem the master mechanic of the Fort Dodge, Des Moines & Southern Railroad Company built a cross pit between the inspection pit and the track on which truck repairs are made. He also designed and built a comparatively inexpensive transfer table of scrap material found



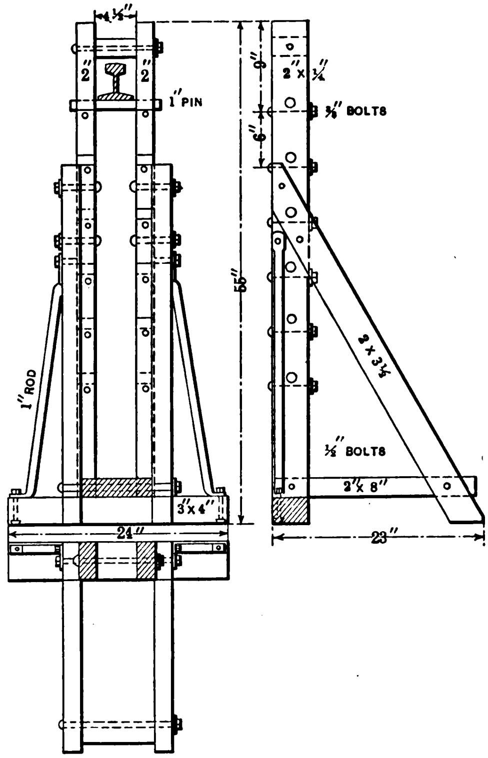
Cross pit truck transfer table.

in the company's storeyard. A sketch showing the transfer table construction as well as the cross pit is shown. The numerals on the drawing give the dimensions of the several parts in inches.

Since the cross pit has been built and the transfer table installed the cost of removing trucks from cars has been reduced to a minimum. An interurban car is run on the inspection track so that the trucks rest on the table. Two jacks are placed under the side sill of the car and bear on the concrete cross pit walls. After the carbody has been raised to a sufficient height to clear the center bearing plates, the transfer table is pushed by hand to the truck repair track, where the defective truck is removed and one in good order replaces it on the table. The transfer table is then moved back to the inspection track, the carbody lowered, the king pin dropped in place, and the car is again ready for the road.

Convenient Car Horse Used in Denver.—The accompanying illustration shows a home-made type of car horse used in the shops of the Denver

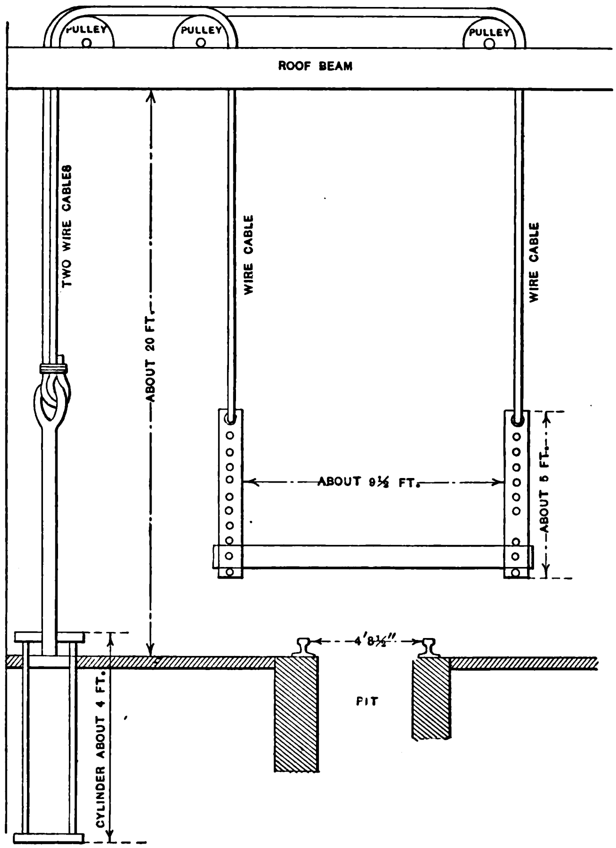
City Tramway Company in place of the usual pair of barrels required to hold a carbody in position in the absence of a truck. The horse is built of oak members, 2 in.×4 1/4 in. in cross-section, the timbers being braced at the bottom of the framing by two 2-in.×3 1/2-in. pieces and tied together at intervals by 3/8-in. bolts. The horse is also braced at the bottom by 1-in. rods bent to an upset which is bolted respectively to the base and upright members. The small bolts tying the structure



Plan and elevation of car horse, Denver.

together are spaced 6 in. apart on centers. The horse is 55 in. high, and is provided with a 4 1/2-in. spacing block at the top. The two principal members are bored at six levels 6 in. apart on centers for the insertion of a 1-in. steel pin to carry the cross-rail which supports the carbody end sill. The bottom of the horse can be set in a space 23 in. wide by 24 in. long and about 20 ft. of the lumber are required in its construction. The cost of the horse complete, including labor and material, was less than $3.

An Hydraulic Car Lift, Employing Cables.—An hydraulic car lift of rather unusual design is in service in the shops of the West Penn Railways Company, Connellsville, Pa. A 14-in. cylinder is installed below the floor and near the side wall a few feet distant from the track. From the upward projecting piston two wire cables are carried to the roof trusses and over separate sheaves placed in such positions that the cables drop down on either side of the car to be raised. The cables terminate in wrought-iron links which support the cross-bar under the car. Admitting water on top of the piston lowers it and raises the car under which the

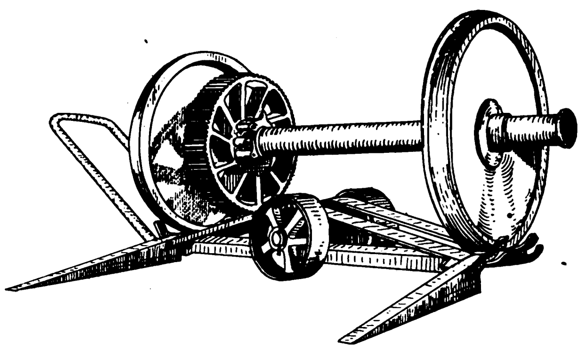


Hydraulic car lift, employing cables.

cross-bar or rail has been placed. This hoist has several advantages over the direct acting type usually found in shops, as the pull is always equal on both ropes and the carbody is raised without cross-strains. The absence of pistons projecting out of the floor affords a free space to work, and as only two cylinders per car are required, the installation is cut almost half.

Repair Shop Car Wheel Truck.—The mechanical department of the Duluth Street Railway Company, Duluth, Minn., uses a wheel truck of original design to move a pair of wheels from a storage yard adjoining the shop building to the wheel lathe and press. While it would be just as easy to roll the wheels by hand between these points as to truck them, the new plan obviates the danger that the shop floors will be damaged by sharp or broken wheel flanges when the wheels are removed from one point to the other.

Essentially, the truck consists of a pipe carriage balanced on a pair of 12-in. wheels with 6-in. flanges. The carriage is built of three sections of 1 1/4-in. extra heavy wrought-iron pipe, which taken together form two simple trusses, or the truck side frames. The bottom members of both side frames and the handle used in moving the truck about the shop are formed of a single section of pipe, containing four bends. The upper members of the side frames are bent at the center and flattened at the ends. Both members of each side frame pass through a special cast



Car wheel truck loaded, Duluth.

bearing provided for the axle of the truck wheels. The length of the axle of the truck is sufficient to allow approximately 18 in. of clearance between the wheel flanges. The flattened ends of the pipe which forms the upper members of the side frames are turned up so as to prevent longitudinal movement of a pair of wheels. Plates riveted between the upper and lower members of the two side frames at the car wheel gage lines connect the two side frames, and the car wheels rest on them when in position to be moved. These plates project about 4 in beyond the side frame on each side of the truck and, together with two 24-in. wedge-shaped wooden blocks which are inserted beneath them, serve as inclines over which the wheels are loaded onto the truck. The upper members of the side frames are riveted to the tops of these end connecting plates and serve as stop blocks to prevent the car wheels from rolling off the truck when it is in motion.

Two men are required to load a pair of wheels, and one man readily wheels the loaded truck about the shop. The complete truck cost approximately $12, including material and labor.

An Inspection Pit Safety Device.—The protection of employees has received a large amount of consideration in the Jersey City shops of the Hudson & Manhattan Railroad, which are in charge of P. V. See, superintendent of car equipment. One of the safety devices in use there is an automatic apparatus which replaces the time-honored practice of calling out in a more or less audible voice "Juice on car No. 732" before the current is put on a car. The new contrivance not only gives a clear warning whistle ten seconds before the current is put on the cars, but it also keeps up this warning as long as the current remains on any of them.

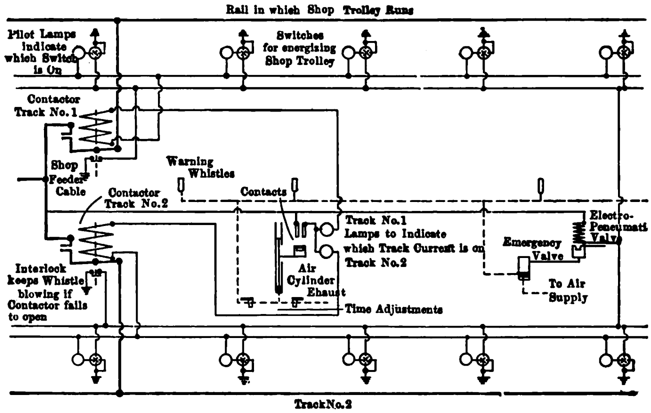


Diagram showing complete circuit of inspection pit safety device, Hudson & Manhattan shops.

The whistles used are high-pitched and of disagreeable sound quality. Hence they are more effective than an ordinary audible warning because their annoying and persistent character forces the repairmen to keep the current on the car no longer than absolutely necessary. Before the installation of this apparatus the current was often on the contact shoes for an hour or two at a time. Now the cars are not alive more than ten or fifteen minutes a day and usually about one minute at a time.

The apparatus consists of four Westinghouse air signal whistles which are equally placed throughout the length of the 400-ft. inspection pit, one electropneumatic valve, two contactors and one piston with contacts. The accompanying diagram shows the complete circuit. When a switchman desires to move a car he proceeds as follows:

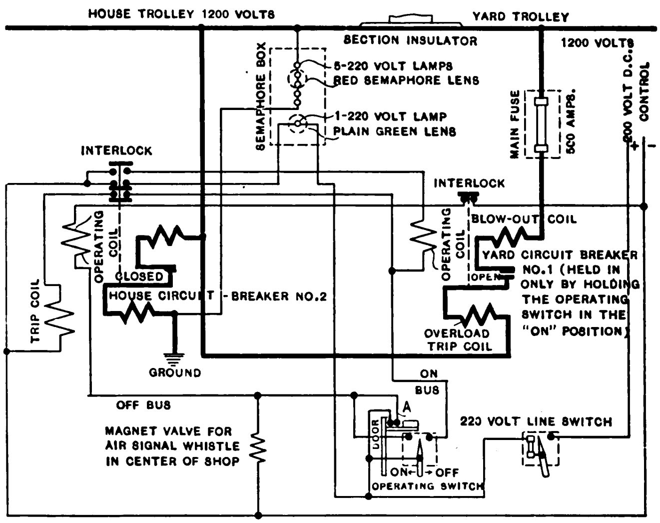
He first puts the Coburn trolley, which is dead, into the car and turns on one of the snap switches which are mounted on the neighboring wall. This switch has a double circuit, one point making a ground for the No. 1 or No. 2 contactor shown, depending on the side of the car-

14

house. The same switch also completes the circuit for the magnets, which operate the air whistles, by grounding them. The whistles then start to blow.

On the air line with the whistles is a brass tube with piston which is connected to a heavy weight A small adjustable leakage valve near this piston regulates the building up of the air-pressure in this line. As the pressure increases it raises the piston and weight. Four contact fingers are fastened on this weight. When the piston is raised to the top of its stroke it makes contact with two other fingers, thereby completing the circuit for the No. 1 or No. 2 contactor, picking it up and energizing the Coburn trolley. When the switchman turns off the snap switch the trolley removed from the car is no longer alive, and there is no possibility that the operator will receive a shock should the insulation on the cable be defective.

Protection of Workmen at Southern Pacific Electric Shops (Abstract of article originally published in the *Travelers' Standard*).—When moving



Wiring diagram of safety circuit breakers, Southern Pacific shops.

cars into or out of the electric railway shops of the Southern Pacific Railway, Oakland, Cal., it is necessary to energize the overhead line with 1200 volts. A green light installed over each track at one end of the building indicates that the line below it is grounded, and not energized, while a corresponding red light indicates that the line is energized, with 1200 volts potential. If the line is not energized but is not grounded neither light shows. Furthermore, an alarm whistle is located near the center of the building, and one blast is given upon it when the line is about to be energized. By repeatedly throwing the operating switch to the "off" position the whistle is then made to sound the number of the track on which cars are to be moved. Upon hearing the whistle all employees who may be working on or about the cars are supposed to stand clear of the cars and the overhead line and to wait for the appearance of the red light. If it should appear over the track on which a man is employed he must not return to work until the line is again cleared and grounded, as indicated by the return of the green signal. The switches governing the energizing of the overhead shop trolley wires are under lock and key, and their care rests with the shop foreman.

The yard trolley wire, which is charged continuously to 1200 volts, is insulated from the trolley wire in the shop by means of a section insulator, located at the top of the door frame. The two wires are connected through a circuit-breaker designated in the accompanying wiring diagram as "yard circuit-breaker No. 1," which is protected by a 500-amp. copper-ribbon fuse. Another circuit-breaker, designated as "house circuit-breaker No. 2," serves to ground the trolley wire inside the shop. Both circuit-breakers are located on the wall above the doors, and controlled through a secondary or auxiliary circuit, by means of an operating switch fixed upon the end wall of the building at a point convenient for manipulation from the floor. The operating switch is supplied with current from the 220-volt shop circuit and is protected by a 3-amp. fuse inclosed in the line switch. The operating circuit is so interlocked that the two circuit-breakers operate alternately. Circuit-breaker No. 1 is held in the closed position by the operating circuit, but only as long as the operator holds the switch handle in the "on" position; and circuit-breaker No. 2, when closed by the operating circuit, is held in this position by means of an integral mechanical lock. The operating coil on circuit-breaker No. 2 is connected in parallel with a valve which operates the air whistle. The operating switch is located in a special box, the door of which has a metal contact, indicated diagrammatically at A, which energizes the magnet-valve circuit as soon as the door is disturbed and thus sounds the alarm whistle and gives warning that one of the shop trolleys is about to be energized. A mechanical trigger is also installed in the operating switch box and interlocked with the handle of the switch in such a way that this handle must be moved to the position which energizes the valve magnet and the operating coil on circuit-breaker No. 2, thus insuring that the whistle is sounded before any other operation of the switches can be made. The breaker is closed at the same time, connecting the shop trolley to ground.

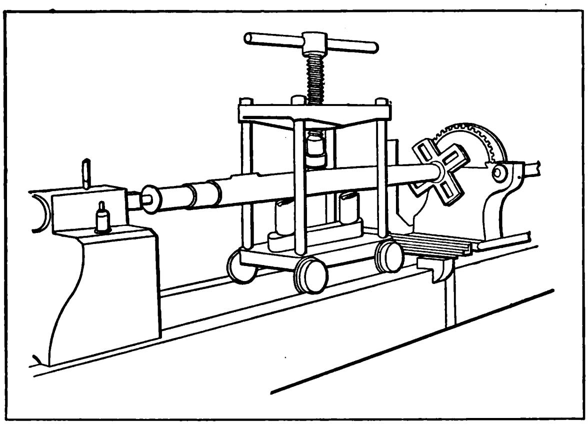
To close circuit-breaker No. 1 it is first necessary to open circuit-breaker No. 2, because the operating coil on circuit-breaker No. 1 and the trip coil on circuit-breaker No. 2 are connected in series with contacts on circuit-breaker No. 2 and interlocked. When the handle of the operating switch is placed in the "on" position the trip coil on circuit-breaker No. 2 is energized, opening the circuit-breaker, and through its interlocks the control circuit for the operating coil on circuit-breaker No. 1 is energized, thus closing circuit-breaker No. 1. Circuit-breaker No. 1 is equipped with an interlock which open-circuits the operating switch to the operating coil of the No. 2 breaker, thereby making it impossible to manipulate No. 2 breaker at an improper time.

When the shop trolley is energized current is supplied to the semaphore lens lamps that show through the red lens. This indicates that the trolley is energized. When circuit-breaker No. 2 is closed and No. 1 is open the green semaphore lens lamps are lighted, and the green light indicates that the shop trolley wire is grounded.

A car is moved in or out of the shop as follows: The shop foreman, as the only one with a key to the switch box, must first be notified. He cannot move the operating switch or the line switch without first opening the door of the box. The act of opening the door automatically blows the alarm whistle in the center of the shop. After the door is opened the foreman must unlock the handle of the operating switch. This act blows the alarm whistle a second time and simultaneously throws current into the operating coils of the circuit-breaker through which the house trolley is grounded—the object being to test the condition of the circuits by insuring that the house trolley wire is grounded at the time the alarm whistle is blown. In the meantime house circuit-breaker No. 2 is held in, mechanically, by a toggle. Hence it is remotely possible that a mechanical shock may have released it and placed the trolley wire in a dangerous condition before the sounding of the whistle. The handle of the operating switch is now in a position where its operation will trip the ground circuit-breaker, relieve the house trolley wire from its ground connection, energize the operating coil of the breaker through which the yard potential is conveyed to the house trolley wire, and change the semaphore lamps from green to red on the trolley wire energized.

When the car movement is complete and it is desired to clear the house trolley wire, the operations take place in the reverse order, with this important difference—that in case the foreman neglects to throw the handle of the operating switch into its locked position and thereby to energize the operating coil of the house circuit-breaker through which the house trolley wire is grounded, his omission is rectified automatically by a mechanical connection on the switch door, by means of which the handle of the operating switch is placed in its normal closed position. It thus energizes the operating coil of the ground circuit-breaker and sounds the alarm whistle to indicate to the men that the potential has been cut off from the house trolley wires.

A Novel Axle Straightener.—The mechanical department of the Little Rock (Ark.) Railway & Electric Company has had in service for some time a home-made axle straightener which is used for either hot or cold straightening of bent axles and shafts. As shown in the illustration, the device consists of a substantially built carriage mounted on an ordinary lathe bed, two bearing blocks which may be raised or lowered by a set of shims and a 3 1/2-in. screw which passes through the upper casting of the carriage. A swivel bearing at the foot of the screw comes in contact with the axle between the two bearing blocks so that kinks may be taken

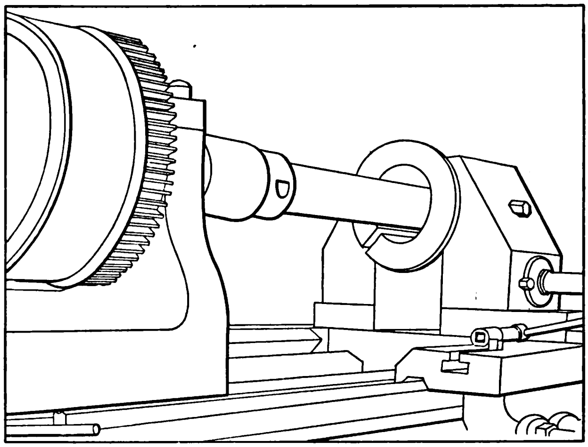


Axle straightener, Little Rock.

out of the axle without putting a strain on the lathe centers. The device is light enough to be readily removed from the lathe bed whenever it is desired to use the lathe for other purposes.

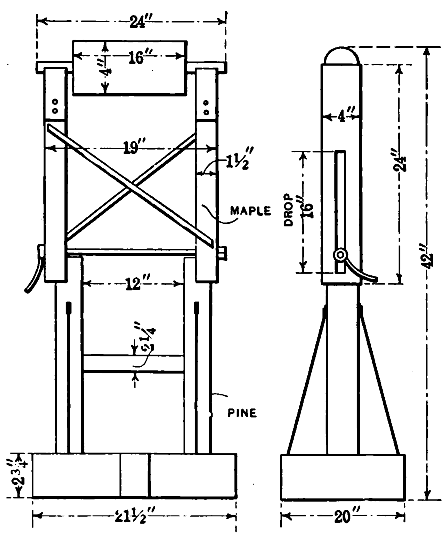
Lathe Attachment for Boring Bearings.—To reduce to a minimum the time required to center rebabbitted bearings in the lathe, C. W. Day, master mechanic Oklahoma Railway Company, of Oklahoma City, has designed and built a self-centering bearing boring attachment of which view is shown on page 204. This is made up of two jaw castings mounted on the lathe carriage and permanently connected by a right and left screw. They are kept in line with the lathe centers by a fork screwed into the exact center of the carriage, the two prongs of this fork engaging with a groove cut at the center of the right and left screw shaft. An extension of the right and left screw through the jaw casting on the operator's side of the lathe permits the jaws to be opened or clamped firmly on the bearing to be bored by turning a hand wheel.

In combination with the self-centering bearing boring attachment a special boring bar has been provided which is set in position between the headstock and tailstock. The end of the boring bar mounted on the headstock has been tapped out so as to take the place of the lathe chuck and the cutting tool is wedged in a slot in the bar. The length of the bar permits the use of two cutting tools, one for the roughing out and the other for the finishing out, making the boring of a bearing complete with one



Lathe attachment for boring motor bearings, Oklahoma City.

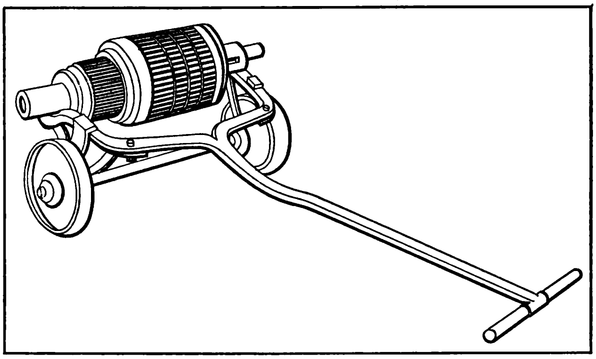
operation. The complete attachment costs approximately $40 and has more than paid for itself by improved workmanship in the bearings bored.



Lumber roller for handling long timbers, Worcester.

Handling Long Timbers.—To facilitate the handling of long timbers at the shops of the Worcester (Mass.) Street Railway, two horses with roller attachments have been developed by the foreman of the department. As shown in the sketch on page 204, each consists of a 16-in. oak roller, 4 in. in diameter, supported on a maple and hard-pine adjustable frame having a range of 16 in. in height above the floor, the frame being locked in position by a hand-turned bolt at any desired point.

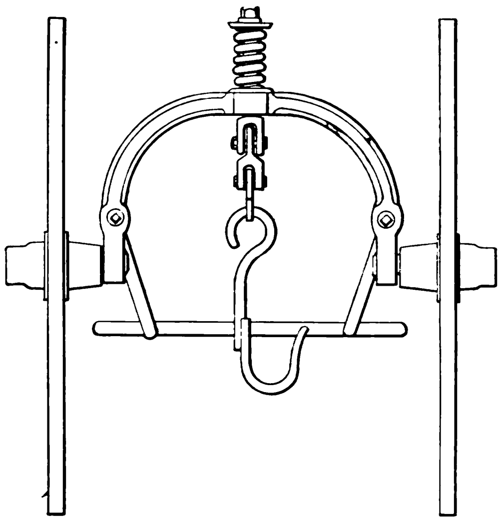
A Handy Armature Truck.—The armature shop of the Pittsburgh Railways Company is in a building separated by an alleyway from the truck repair shop. All armatures going to or from the shop have to be hauled 100 ft. or more across this alley, and a convenient form of truck has been devised for this purpose. It consists of a pair of iron wheels, 12 in. in diameter, turning loosely on an axle. Mounted on this axle is a forked iron frame terminating in a long handle and cross-bar. The forked arms are curved downward to form a resting place for the armature



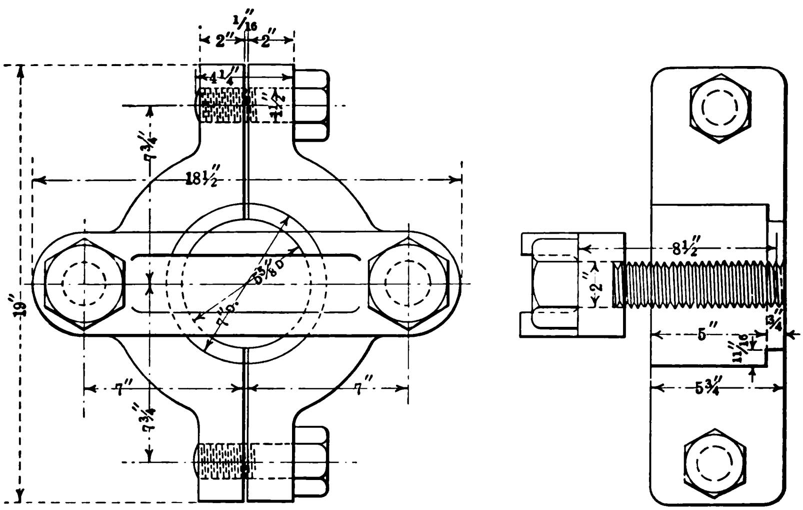
Handy armature truck, Pittsburgh.

shaft. By elevating the handle of the truck the forked arms can be lowered and pushed under the shaft of an armature lying on the floor. When the handle is lowered to about waist height the armature is lifted clear of the floor and the truck can be moved anywhere about the shop.

An Armature Wagon.—Among the labor-saving devices at the Cold Springs shops of the International Railway Company is the armature wagon which is shown in detail in the top drawing on page 206. The wagon proper consists of a cast-iron arched trunnion supported on two carriage wheels. A shaft with a cross-handle bar is bolted to the trunnion. The chief novelty is the use of the compression spring to aid in picking up and carrying armatures. Two steel hooks are carried from the two ends of a cross-bar flexibly hung from a bolt which passes up through the top of the arch and through the compression spring. This bolt is threaded at the top for a nut. In use the arch is tilted first one way and then the other, thus allowing the hooks to pick up an armature from the floor. The device is very light, easy to manipulate and durable. The spring support produces such a good cushioning effect that the wagon can be run rapidly on an uneven floor without risk of injury to the armature. This armature wagon was designed by W. H. Evans when he was master mechanic of the railway.



Front view of armature wagon, Buffalo.

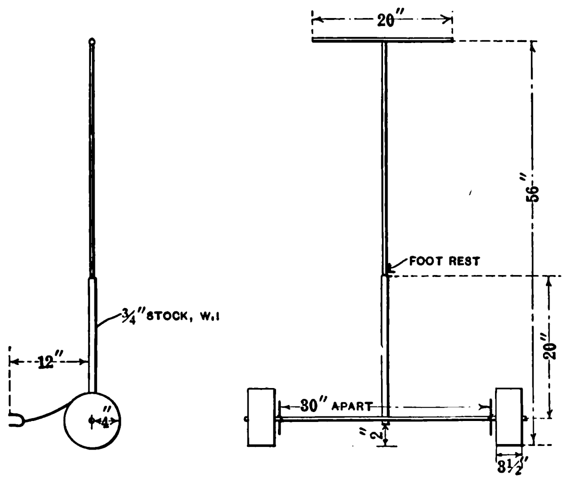


Details of pinion puller, Columbus.

Ingenious Pinion Puller.—The mechanical department of the Columbus Railway & Light Company has designed and manufactured a pinion puller the detailed construction of which is shown herewith. Several different sizes of pullers have been manufactured to fit the different-sized pinions used in the various equipments. The device is comparatively light and the cost of manufacture low, owing to its simple construction.

The pinion puller consists of a cast-steel ring made in two sections which are held together by two stud bolts. The inside diameter of the ring is the same as the over-all diameter of the pinion. One diameter was reduced, however, by cutting 1/32 in. from the adjoining faces of each section so as to permit the ring to be clamped tightly in position should the pinion be worn. A 1/16-in. shoulder is provided at the back of the inside cylinder which furnishes the bearing against which the teeth rest in the removing process.

The yolk is of cast steel and is fitted with two 2-in.×8 1/2-in. stud bolts, which screw into lugs provided on the sections of the pulling ring. The liberal length of these bolts permits of the adjustment of the yoke to the proper working position. A section of shafting of sufficient length to permit the pinion to be removed from the shaft with one application of the puller is inserted between the yoke and the armature. This furnishes a bearing for the yoke on the armature shaft and permits the two bolts which clamp the yoke to the pulling ring to be tightened to a point where the pinion is forced from the shaft.

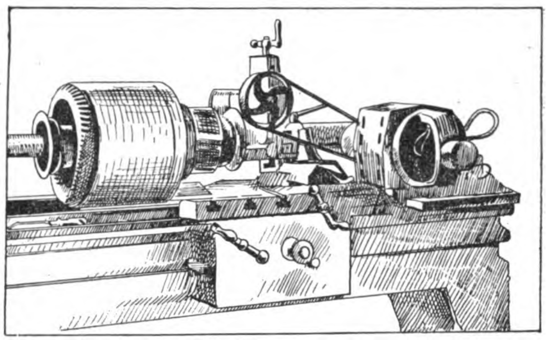


Armature truck of skeleton type, Worcester.

Armature Truck of Skeleton Type.—Among the labor-saving devices in use by the Worcester (Mass.) Street Railway is an armature truck of the skeleton type shown in the sketch on this page. This truck has two 8-in. wheels with 3 1/2-in. treads and a 20-in. handle carried 56 in. from the floor at the top of a 3/4-in. wrought-iron bar carried to the center of the wheel shaft. A foot rest is provided on the main bar 20 in. above the floor. The armatures are carried on U-shaped holders forged at the ends of extension pieces 12 in. long. The truck design permits the handling of armatures on the cantilever principle, and the balancing of the equipment is one of the convenient features of this home-made device.

Lathe as Slotter and Bander.—On the Hudson River & Eastern Traction Company's lines the grades are severe and the motors have to be operated under arduous conditions. Hard brushes are used which keep the motors running but are hard on the commutators, and some time ago H. E. Kay, master mechanic, came to the decision that it would be desirable to slot the commutators to overcome the rapid wear.

In consequence, a commutator slotter, as shown in the accompanying illustration, was made up in the shop from materials easily procured and

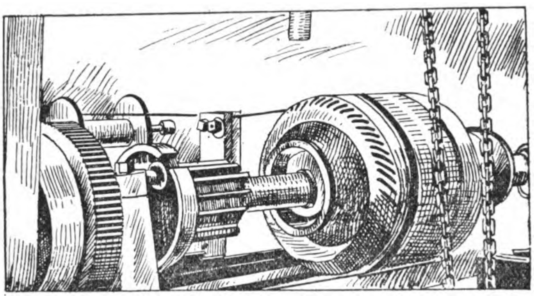


Engine lathe equipped for slotting commutators, Hudson River & Eastern Traction Co.

at a practically negligible cost. With this Westinghouse No. 49 motors having 117 slots in the commutator can be slotted in forty minutes. The slotting equipment, which is applied to one of the standard engine lathes in the shop, consists of a piece of board bolted to the T-slots on the lathe carriage, upon which is clamped a small motor, the clamps permitting easy alignment for the belt. An iron bracket bent at right angles is bolted in the slot in the tool carriage, from which the tool post is removed, and to the vertical side of this bracket is bolted an old slide rest set vertically, thus permitting the raising or lowering of the bearing for the saw arbor, which is bolted to the old slide rest in place of the original tool post. The arbor or shaft which carries the saw is equipped with a pulley on the opposite end, and over this is run a belt to the pulley of the small motor.

The slotter permits horizontal adjustment of the saw by moving the tool carriage of the lathe in or out in addition to the vertical adjustment obtained through the use of the vertical slide rest. It is also possible, by shifting the tailstock, to follow with the saw any segments which are not in perfect alignment with the armature shaft.

The same lathe is also used for a banding machine, as shown in another illustration, by running the lathe at the lowest speed, or 11 r.p.m., tension being put upon the wire by means of a slotted stick of maple with bolts through the end to clamp the wire between the two sides of the slot. This stick rests against the rear of the lathe bed. The wire is carried on an ingenious home-made reel. This was cast in iron, using a bell-cord spool for a pattern. After the ends of the spool were faced off and centered a small hole was drilled through the core so that the wire could be attached when the process of winding was begun. Two 7/8-in. bolts

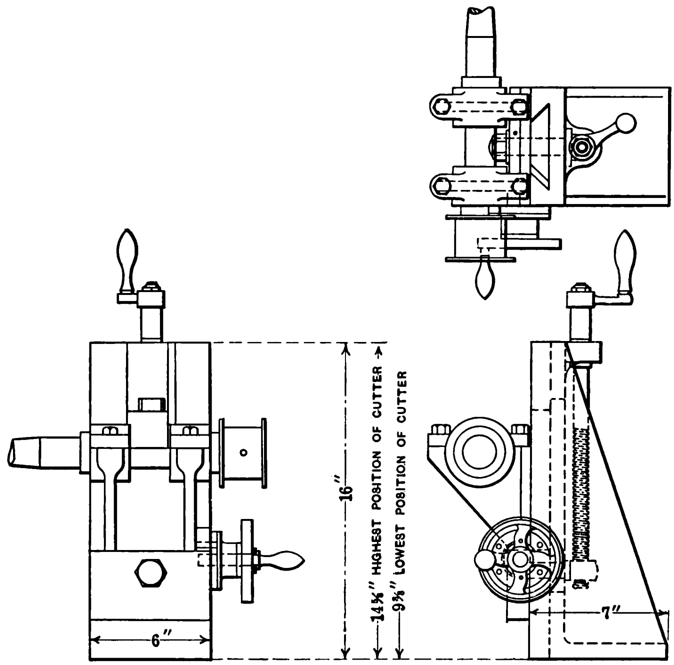


Engine lathe equipped for banding armatures, Hudson River & Eastern Traction Co.

were then pointed to match the centers in the spool ends and screwed into tapped holes in angle-iron brackets, which in turn were mounted on the wall back of the winding lathe. As the pointed bolts have set nuts to lock them after insertion in the spool center, they act as a brake to keep the spool from unwinding too rapidly, and they can be adjusted to give any desired tension.

Commutator Slotting at Boston.—It is the practice of the Boston Elevated Railway to coarse-file all commutators after the undercutting is done, leaving a slight burr or fin on the inside of the slot, which is then removed by hand with the use of a steel knife. This cleans out particles of mica. The slotting is performed with an air jet blowing upon the tool. The commutator is gone over with a fine file and sandpaper, and the air jet is used continually while the sandpapering is in process. The slotting tool is driven by a spindle belted to the counter-shafting above the lathe, tension being provided by two idlers carried on a spring rod held above the head of the operator. The company has found that the most scrupulous care needs to be taken in doing undercutting work, and that hasty slotting is apt to lead to more trouble than the process saves. For this reason no special effort has been made to perform undercutting in quicker time than is the case elsewhere. It has been found desirable to allow an hour for cleaning out the undercut channel between the bars. If the work is hurried too much it is likely to leave thin edges of the mica next to the undercutting, with the result that the brushes ride unevenly on the commutator and cause sparking.

A working drawing of the tool holder, which fits an ordinary lathe, is shown in the accompanying cut. The slotting tool is mounted on a shaft driven by a spindle carried in the bearing shown in the side elevation, and maximum facility of adjustment is afforded by the horizontal and vertical spindles illustrated. The cutting tool can be raised to a maximum height of 14 5/8 in. above the ways of the lathe, and lowered to a height

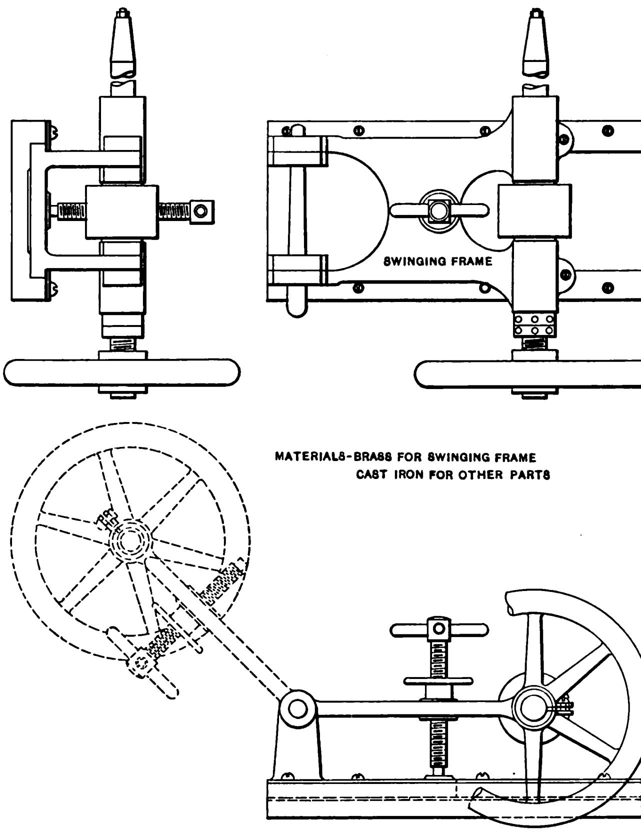


Details of commutator slotter, Boston.

of 9 3/8 in. above the bed. The maximum width of the frame supporting the tool and driving pulley is 7 in. The device may be locked on the carriage of the lathe with ease.

A Commutator Slotter (By H. P. Clarke, Former Master Mechanic, New York Railways Company).—During recent years the advantage of slotting commutators has been so fully recognized that the practice has been generally adopted by the leading street railways of the country. With the value of this practice fully established a great many different devices have been evolved for doing this work. A few years ago the writer caught the infection so prevalent at the time, with the result illustrated in the drawing on page 211.

The idea was to develop something simple and efficient, readily fitted up in the ordinary repair shop at small cost. The device shown consists of a slide rest which carries a small swinging frame and saw arbor fitted with a circular saw. The frame is carried on a taper pin which is similar to the apron of an ordinary planer or shaper. This arrangement provides a simple means of adjustment for commutators of different diameters and also allows the saw to be thrown back out of the way when handling the



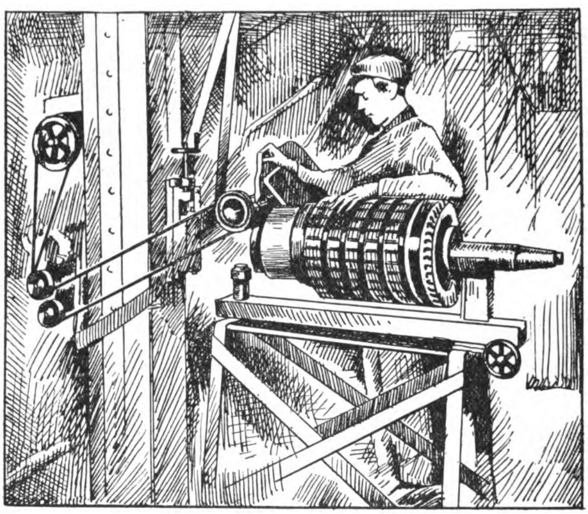
Swinging frame for commutator slotter.

armature. A handle is fastened to the swinging frame as shown, and the saw is drawn through the commutator. It was found advisable to use a coiled spring for holding the saw down to the mica. This spring is fastened to a staple in the floor and hooked over the handle. The spring can be released and the frame thrown back in an instant.

In the present case this device was fastened to a banding lathe, also of the writer's design. This slotter has been in constant use for the past three years, and has proved very satisfactory and efficient. An armature such as the GE-57, 80 and 1000 and the Westinghouse No. 56 can be readily undercut in from ten to fifteen minutes.

After the slotting feature was perfected the machine was arranged for revolving the armature at high speed, so that the burrs thrown up by the saw could be removed and the commutator polished at one operation. Two side screws provide for the adjustment of the slide rest for commutators that are not in exact alignment with the shaft, but such adjustment is seldom required. As the armature is held very free on the centers, the saw follows the cut without trouble. This slotting rig can be readily attached to any lathe and has no expensive adjustments or heavy moving parts.

Louisville Railway Slotting Machine.—The mechanical department of the Louisville Railway Company has designed and built an inexpensive yet efficient commutator slotting machine in its shops at Louisville, Ky.

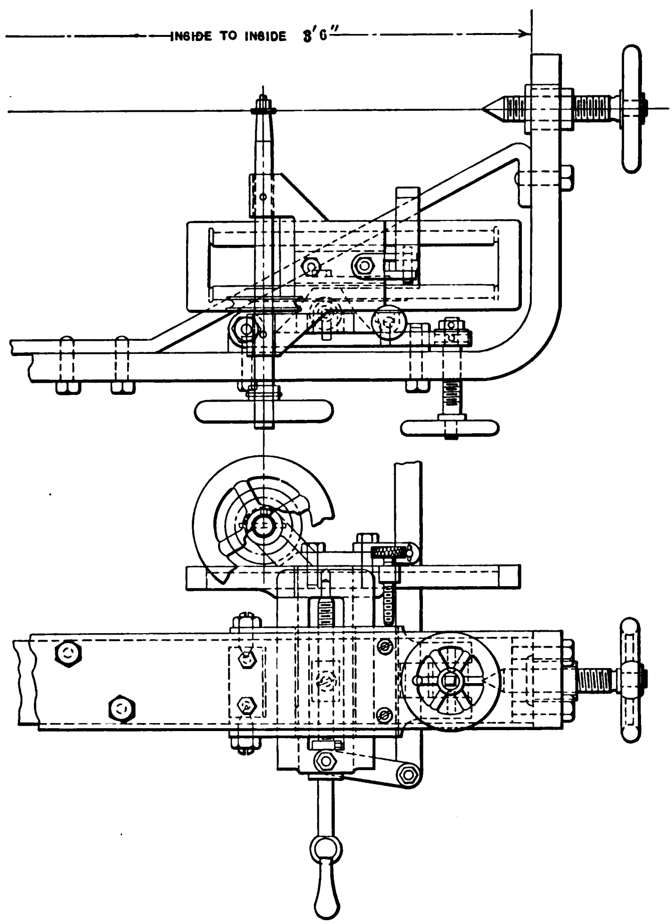


Commutator slotter, Louisville.

It is mounted on one of the building columns and is belt-driven from a line shaft which passes through the armature shop. It consists of a guide casting bolted to the building column at the top of which a handwheel has been applied to a screw which raises or lowers the bracket supporting the slotting saw to the proper working elevation. The slotting saw is mounted on a cast-iron bracket which is provided with a rack and pinion. By applying a crank to the pinion shaft the slotting saw is forced horizontally to the cutting position. A circular leather belt, which is kept taut by a pivoted trolley wheel idler, drives the slotting saw and the whole is controlled by a foot lever friction clutch mounted on the line shaft.

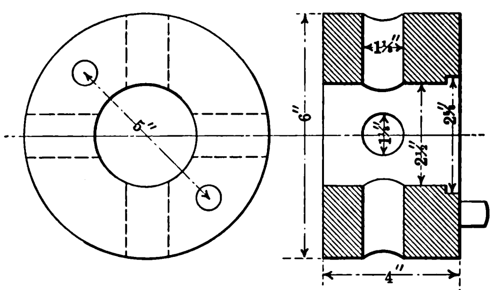
The armature support is constructed of structural steel with cast-iron armature shaft-bearings. The support is mounted on wheels so that the armature may be raised to the support by the overhead traveling hoist and moved easily to the slotting machine. The whole outfit did not cost to exceed $20 and a Westinghouse-69 armature has been slotted in twelve minutes.

Improved Commutator Slotter.—A master mechanic on a large western railway devised some years ago a commutator slotter suitable for com-



Improved commutator slotter, devised on a western railway.

mutators of any diameter. The construction details are shown in an accompanying drawing. The working parts are constructed mainly of wrought iron, but brass bushings are used for the saw spindle; the standard or armature support is constructed of two 3/4-in. wrought-iron forgings held together by 1/2-in. rods running through 3/4-in. gas pipes. This gives the whole machine a strong yet light appearance after the saw has been swung clear of the center. The armature first is brought to the stand by a chain hoist. The wrought-iron yoke which carries the centers for the armature shaft and machine proper is now swung into position to bring the saw in line with the center of the commutator. The centers are then tightened on the end of the armature shaft to insure rigidity. The spindle is connected to a belted, grooved pulley running 1500 r.p.m. and has a 3/4-in. diameter circular saw. The latter is held in position by a nut at the end of the shaft so that worn saws may be easily replaced. Adjustment for different sizes of commutators is obtained through a hand screw below the centering frame, which raises or lowers the saw shaft to the proper position and depth of cut, as checked by a thumb screw. The hand wheel at the side is for adjusting the saw when segments of the commutator are not in line with its shaft center. After this adjustment the workman slots the commutator by pushing the lever toward the armature and moving the sliding carriage which supports the spindle for the saw. The saw runs clockwise facing the front of the machine. With this device the commutator slots of a Westinghouse 38-B motor, which has 135 commutator segments, can be cut 3/32 in. deep in from ten to twenty-five minutes, according to the hardness of the mica. A hose conveys compressed air to keep the commutator clean and free from mica dust.

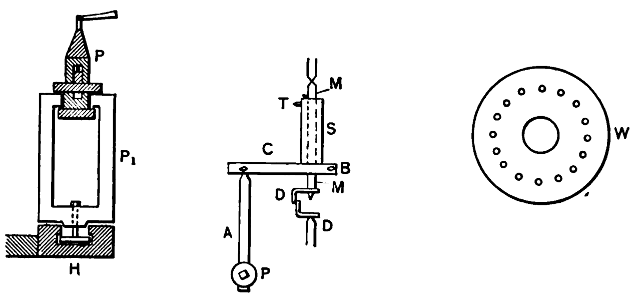


Wrench for commutator jam nuts, Chicago.

Wrench for Commutator Nuts.—An accompanying sketch exhibits the detail dimensions of a special wrench used by the Chicago City Railways for screwing up commutator jam nuts. With this wrench, which is simply a block of iron properly bored and fitted with two protruding pins, it is possible with the assistance of a long bar to exert an enormous pressure on the commutator jam nut.

Wheel Grinding at Syracuse.—A simple method of grinding flat wheels in position is used at the Syracuse shops, New York State Railways. One end of the car is jacked up so that while one set of wheels is blocked the other pair of wheels is lifted freely to be revolved by one motor. The flatted wheel is revolved against an emery block which is set under the wheel. Flats are also removed by spinning the wheel against emery brake shoes. The cooling water used during the grinding process is furnished through a pipe line from the pit.

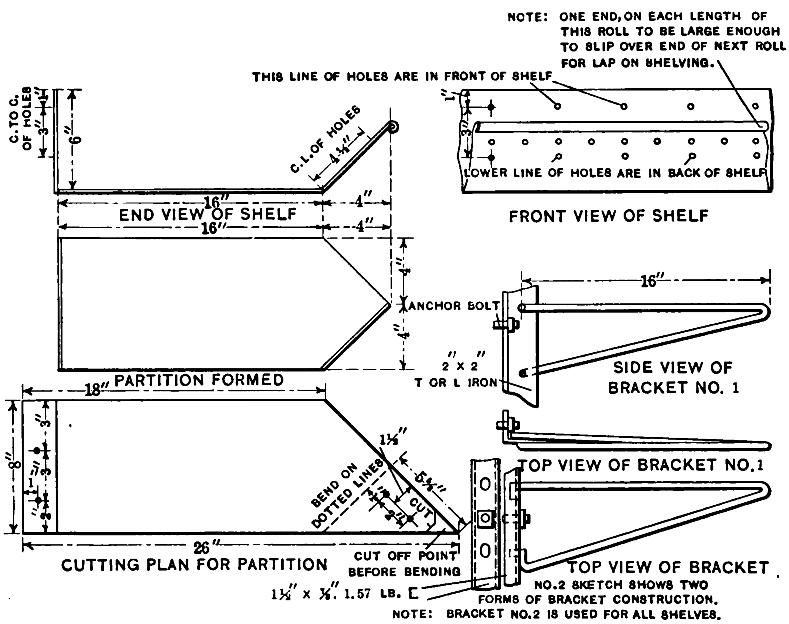
Boring Wheels with a Lathe.—A novel method of boring wheels in an ordinary engine lathe is illustrated in the accompanying sketch. The scheme was developed by George F. Poor, master mechanic of the Asheville (N. C.) Electric Company, and has proved thoroughly successful. *P* is the ordinary tool post of the lathe and *H* the regular compound head rest. An extension tool post P_1, 9 in. high, is used to raise the ordinary tool post above its usual position. This extension piece is 5 1/4 in. wide over all and 3 in. wide inside the frame. It is attached to the compound head rest by the 5/8-in. bolt, nut and plate shown.



Boring wheels with a lathe.

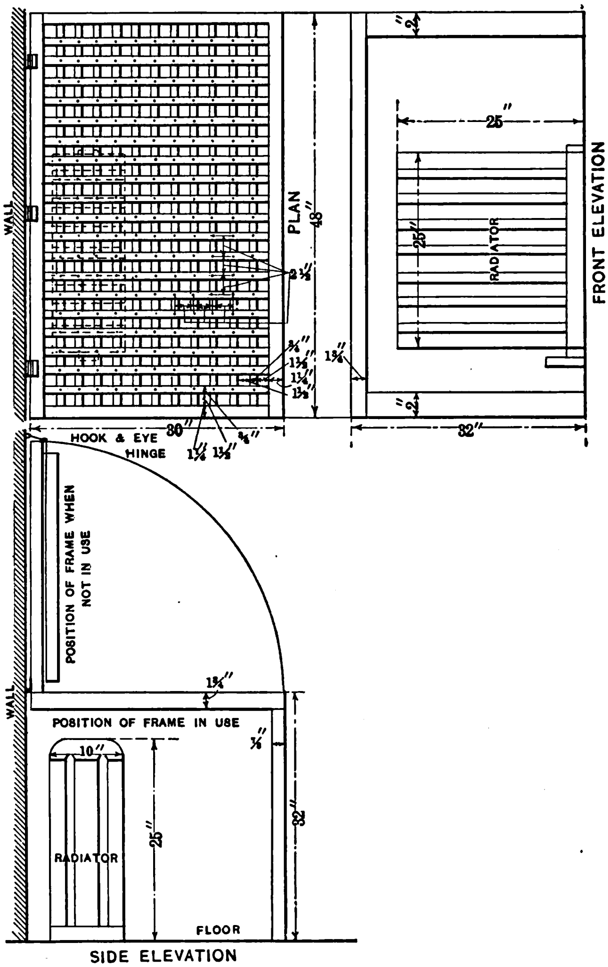
In place of the usual tool a bar *A*, 6 in. long, is clamped into the tool post *P*, and at the end of this bar a clamp *C* is attached by a set screw fastening. This clamp is secured around a sleeve *S* with a bolt-lock at *B*, so that *S*, *C* and *A* are one rigid member. *M* is a stationary mandrel fitting at one end into the head center of the lathe and being held rigidly against the tail center of two dogs *DD*, which are clamped together to prevent the turning of the mandrel, the latter acting simply as a guide for the sleeve *S*. The sleeve *S* is 2 3/4 in. outside diameter, the mandrel *M* having a sliding fit of 1 5/8 in. diameter. Attached to the mandrel near its head is a cutting tool *T* of high-speed steel, which is secured in a hole in the mandrel by a 3/8-in. set screw. The lathe is also provided with a head stock extension 9 in. high and a tail stock extension of the same dimension, and the lathe is driven by a short belt from the usual overhead pulleys.

In operation the wheel is placed in the lathe by being attached to a 35-in. face plate *W* in which are 14 3/4-in. holes drilled on a circumference. The face plate fits the lathe spindle and the wheel is attached to the face plate by the clamps. The tool *T* is then adjusted in the sleeve, the latter being rigidly fastened to the tool post. When the latter is started the wheel revolves with the face plate, and the tool post, bar clamp *C*, sleeve *S* and cutting tool *T* feed along the lathe parallel to the mandrel or line between centers. The adjustment thus permits the tool *T* to advance along the bore of the hub inside, as the latter revolves, and all lost motion is prevented by the fit of the sleeve on the mandrel and the fastening of the latter to the tail stock center. In this way the lathe (an 18-in. machine) is given a 36-in. swing and the travel of the cutting tool *T* can reach a maximum of 6 in. parallel to the center line of the lathe. A wheel can be bored out in about an hour with this device and the cost of fitting it up was considerably less than $200. Aside from the saving in the cost of a boring mill there is a saving in the cost of having the job done outside and in the time required.



Details of storeroom shelves, Syracuse.

Storeroom Shelves at Syracuse.—The design of the storage bins and shelves at the Syracuse shops of the New York State Railways merits special attention because of the simple means provided to change at will the size of individual bins and the spacing between the shelves in accordance with changes in the character of materials handled. These bins are of galvanized iron and are built up as follows: Carrying channels are bolted vertically to the wall at 26-in. centers and are perforated for the insertion of the shelf brackets at any desirable intervals. The shelving consists of horizontal sections 12 ft. long which have a series of holes 4 in. apart so that the vertical partitions can be riveted to the shelf at intervals of 4 in. or multiples thereof. The general construction details of the bins and brackets are presented in an accompanying drawing which also shows



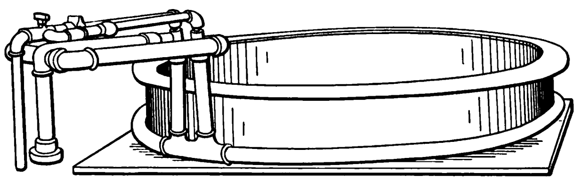
Blueprint drying frame.

how the front edge of the shelving is rolled up for lapping over the next 12 ft. to secure an unbroken construction. Each bin carries a holder with a printed card which gives the bin number, the name of the article and the catalogue number.

A Handy Blueprint Frame.—The accompanying drawing illustrates a blueprint drying frame used in the offices of the Boston Elevated

Railway Company in a pent house on the roof of the Milk Street headquarters. It was designed by H. C. Hartwell, of the elevated and subway engineering construction department, and was built to prevent warping when wet prints are laid upon it over a steam radiator on which the latter are dried when haste is required. The frame is of white pine, halved and screwed at intersections, and is designed to fold up against the wall when not in use. The openings in the lattice work enable the heat to be applied efficiently to the damp prints, and the cost of the frame is trifling.

A Gas Burner for Expanding Tires.—The accompanying illustration shows a simple and inexpensive gas burner for heating tires which has been designed and built at the shops of the Aurora, Elgin & Chicago Railroad Company at Wheaton, Ill. A gasolene burner was formerly used for this purpose, but it was expensive to operate and dangerous as well. A high-proof gasolene was required and it was found to be impossible to store it even in tightly closed metal casks without a loss from evaporation greater than the amount actually burned during the comparatively infrequent use of the burner. Some time was necessary to start



Gas burner for expanding tires.

the burner and it frequently flooded so that the fire had to be put out and the tire allowed to cool down before starting up again. The burner shown was built and, after several experiments were made to determine the proper size and location of the air nozzle, it was made to work with complete success at the surprisingly low consumption of 4 cu. ft. of gas per minute. It requires at the most twenty-five minutes to expand a tire sufficiently to remove it from the center, and with illuminating gas at $1 per 1000 cu. ft., the cost is only 10 cents. Tires have been removed in fifteen minutes at a cost of 6 cents.

The burner is made of 1-in. iron pipe with 1-in. pipe connections for gas and 1/4-in. pipe connections for air. The air and gas pipes are attached by unions to mains run under the floor. The risers divide at the top and join the two halves of the burner which are made separate and overlap at their ends. The air pipes have small thumb cocks inserted in them to regulate the intensity of the blast, but the gas is turned into the burner at the full service pressure of 3 oz. The air pipes are led into the vertical legs of the gas-pipe connections through a reducing T, which is used instead of an ordinary elbow at the upper bend. They are carried down inside of the vertical legs and are bent outward at the bottom to discharge the air directly into the burner pipe. The burners have 3/16-in. holes drilled in them spaced 1/2 in. apart. One of these burners with holes on the inside is used for removing tires, and an exactly similar burner of smaller diameter and with holes on the side is used for expanding tires before shrinking them on centers. The cost is trifling and the burners can be made in any shop equipped with pipe-fitting tools.

CHAPTER XIV

INSTRUCTION PRINTS AND TABLES FOR SHOPMEN

Within the past five years, quite a number of electric railways have done much to insure correct and most economical work in car maintenance by furnishing the shopmen with instruction prints. These prints show the best methods of determining brush setting and motor lead location, of regulating grid resistances, of making proper allowances for controller and motor wiring, of setting heater steps, of wiring for lamps, push-buttons, compressors, etc. Among the companies which have issued prints of this kind are the United Railways & Electric Company of Baltimore, the Brooklyn Rapid Transit System, the Philadelphia Rapid Transit Company and the Public Service Railway, Newark, N. J. Some of the prints, of course, apply only to the conditions peculiar to a given property, but even these will be found of value in preparing other prints to serve the same purpose. For the convenience of the user, the instruction prints following have been placed in the order of subject regardless of their origin. The original prints are made up in handy booklets, usually 6 in.$\times 3\frac{1}{2}$ in. in size. Through the courtesy of the manufacturers, several prints covering recent equipment have been added. Some tabulated matter on resistances, leads, etc., has also been included.

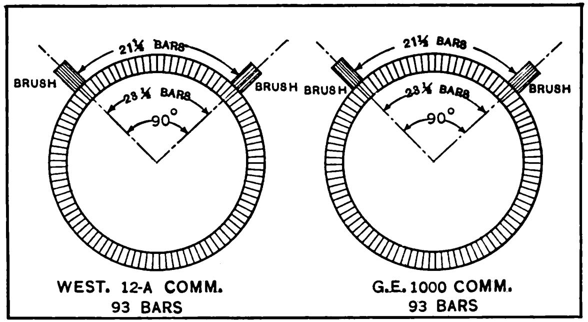


FIG. 1.—Set of brushes on West. 12-A and GE-1000 commutators (P. S. Ry.).

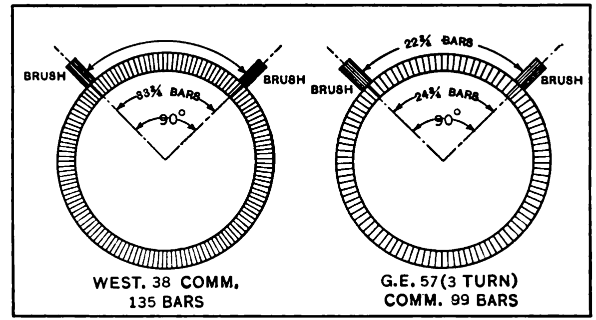


FIG. 2.—Set of brushes on West. 38 and GE-57 commutators (P. S. Ry.).

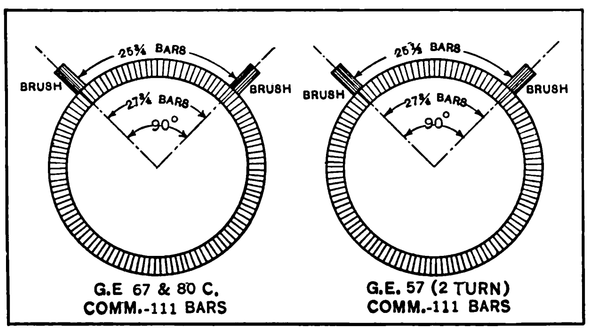


FIG. 3.—Set of brushes on GE-67, 80-C and 57 commutators (P. S. Ry.).

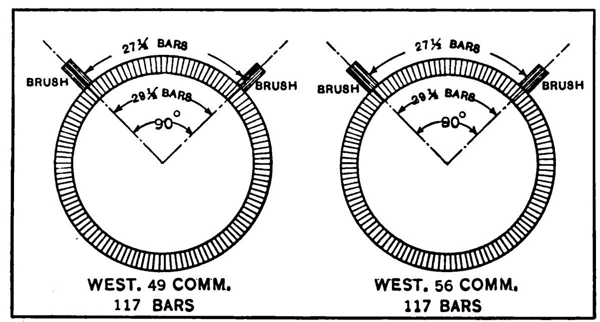


FIG. 4.—Set of brushes on West. 49 and 56 commutators (P. S. Ry.).

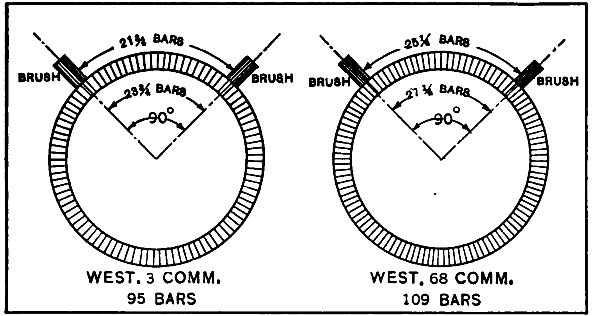


Fig. 5.—Set of brushes on West. 3 and 68 commutators (P. S. Ry.).

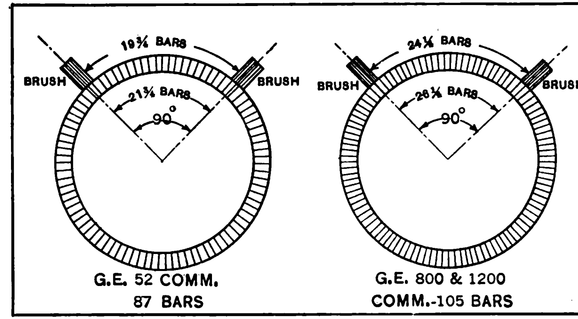


Fig. 6.—Set of brushes on GE-52, 800 and 1200 commutators (P. S. Ry.).

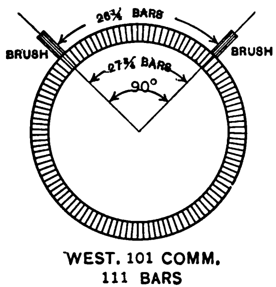
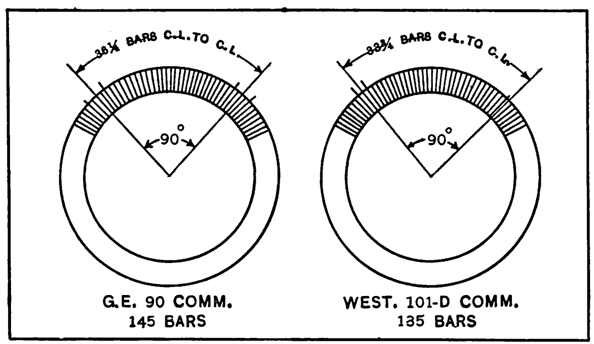


Fig. 7.—Set of brushes on West. 101 commutator (P. S. Ry.).



Figs. 8 and 9.—Set of brushes on GE-90 and West. 101-D commutators (Baltimore).

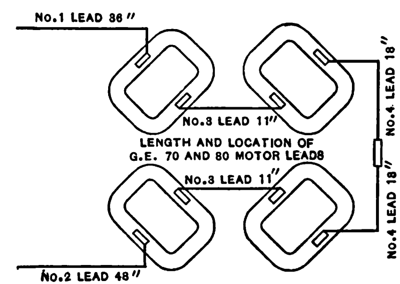
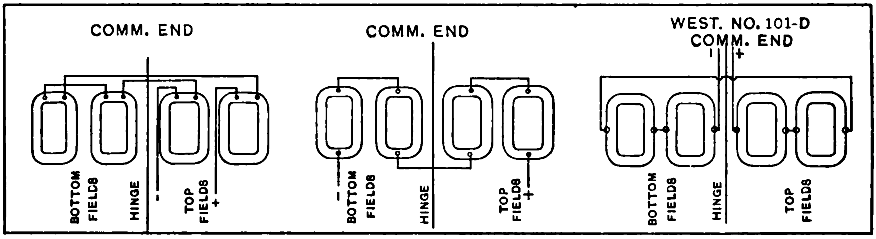
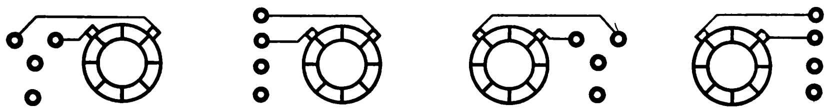


Fig. 10.—Motor lead location and length for GE-70 and 80 motors (Philadelphia).



FIGS. 11, 12 AND 13.—Motor lead locations, West. 49, GE-90 and West. 101-D motor (Baltimore).



Note.—For apparently the same connections, Westinghouse and General Electric armatures (except Nos. 57 and 1000) run in opposite directions.

In all cases, the terminal of the near brush holder issues from the motor through the bushing nearest to it.

FIG. 14.—Opposite rotation for same connections (P. S. Ry.).

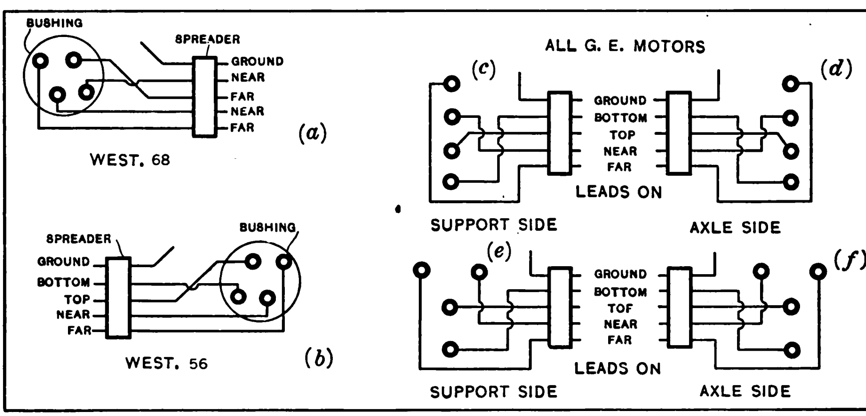


FIG. 15.—Order of bringing motor leads through spreader (P. S. Ry.).

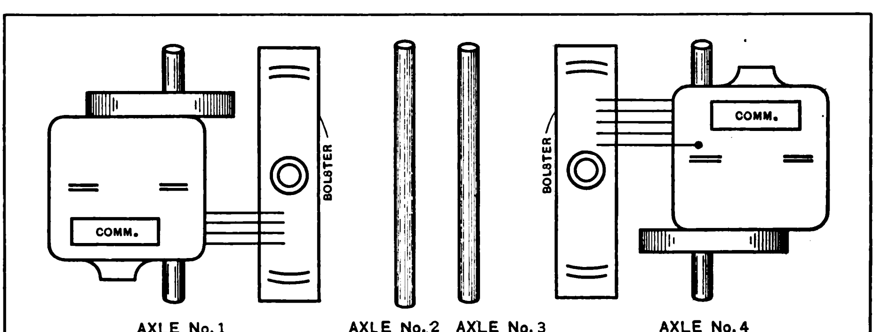


FIG. 16.—Mounting of two motors on two double trucks and corresponding to connections of Figs. 35 and 36; motor terminals brought out on axle side (P. S. Ry.).

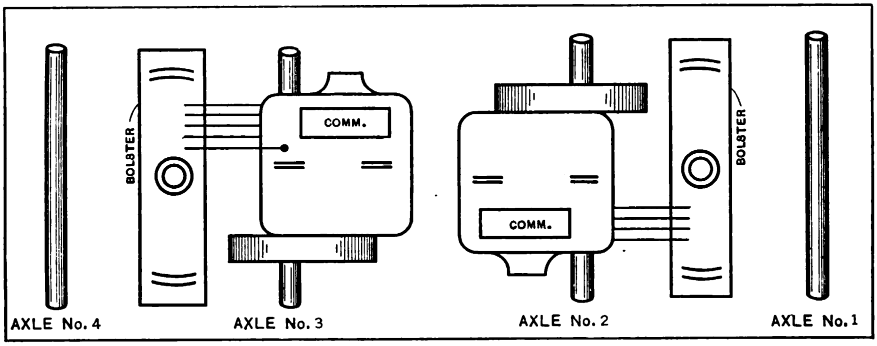


FIG. 17.—Mounting of two motors on two double trucks and corresponding to connections of Figs. 35 and 36; motor terminals brought out on axle side (P. S. Ry.).

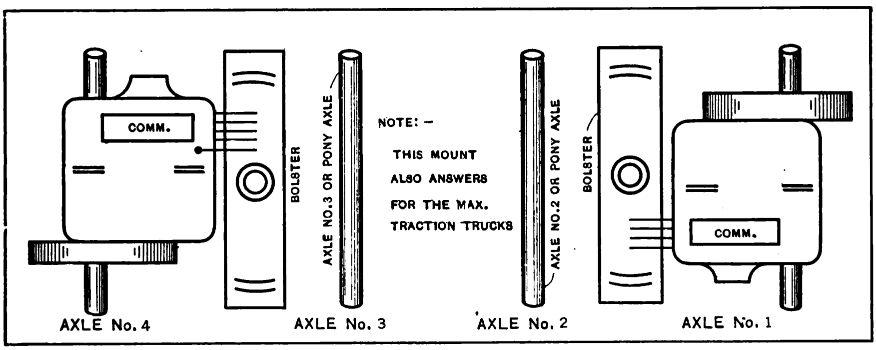


FIG. 18.—Mounting of two motors on two double trucks and corresponding to connections of Figs. 37 and 38; motor terminals brought out on suspension side (P. S. Ry.).

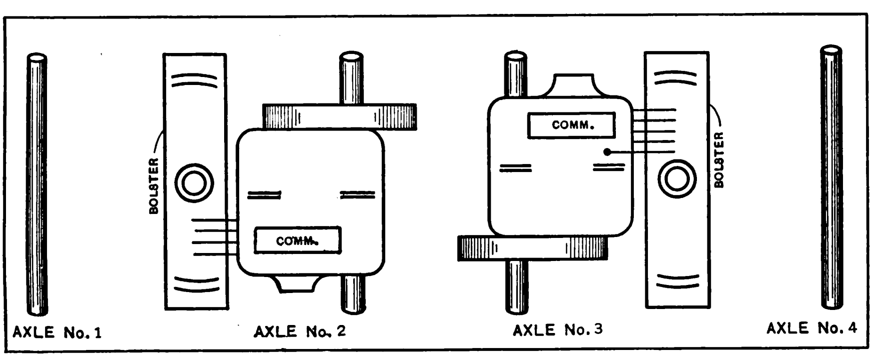
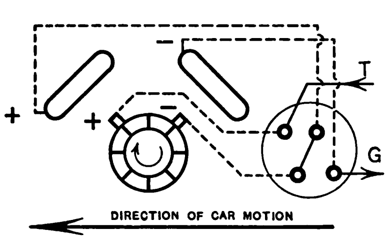
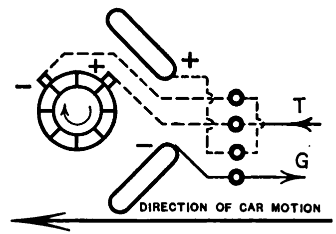


FIG. 19.—Mounting of two motors on two double trucks and corresponding to connections of Figs. 37 and 38; motor terminals brought out on suspension side (P. S. Ry.).



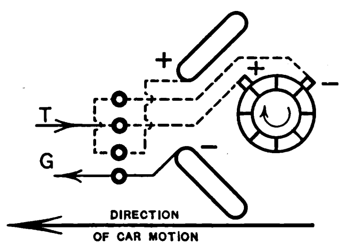
Notes.—In considering connections, face the commutator end. The single A's and F's from controller are plus wires if wiring is correct. When far brush holders and far field are plus, the armature rotates clockwise, and the car moves to the left.

FIG. 20.—Direction of rotation of West. 68 motors with given polarity of fields and brushes and corresponding direction of car motion (P. S. Ry.).



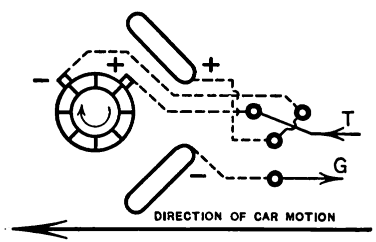
Notes.—In considering connections, face the commutator end. The single A's and F's from controller are plus wires if wiring is correct. When near brush holder and top field are plus, the armature rotates clockwise, and the car moves to the left.

FIG. 21.—Direction of rotation of GE-800, 52, 58, 67 and 80-C motors with given polarity of fields and brushes, when terminals come out on the right, and corresponding direction of car motion (P. S. Ry.).



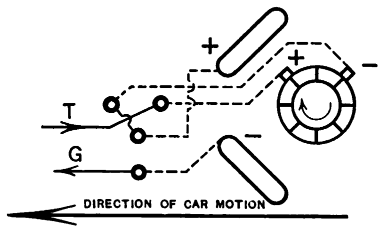
Notes.—In considering connections, face the commutator end. The single A's and F's from the controller are plus wires if wiring is correct. When near brush holder and top field are plus, the armature rotates clockwise, and the car moves to the left.

FIG. 22.—Direction of rotation of GE-52, 58, 800, 67 and 80-C motors with given polarity of fields and brushes, when terminals come out on the left, and corresponding direction of car motion (P. S. Ry.).



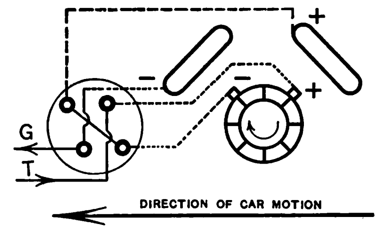
Notes.—In considering connections, face the commutator end. The single A's and F's from the controller are plus wires if wiring is correct. When near brush holder and top field are plus, the armature rotates clockwise, and the car moves to the left.

FIG. 23.—Direction of rotation of GE-800, 52, 58, 67 and 80-C with given polarity of fields and brushes, when terminals come out on the right, and corresponding direction of car motion (P. S. Ry.).



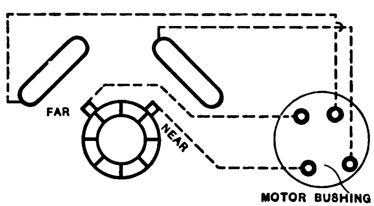
Notes. — In considering connections, face the commutator end. The single A's and F's from the controller are plus wires if wiring is correct. When near brush holder and top field are plus, the armature rotates clockwise, and the car moves to the left.

FIG. 24.—Direction of rotation of General Electric motors (except Nos. 57 and 1000) with given polarity of fields and brushes, when terminals come out on the left, and corresponding direction of car motion (P. S. Ry.).



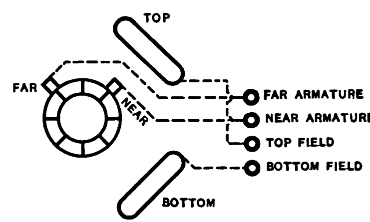
Notes. — In considering connections, face the commutator end. The single A's and F's from the controller are plus if wiring is correct. When far brush holder and far field are plus, the armature rotates clockwise, and the car moves to the left.

FIG. 25.—Direction of rotation of Westinghouse 56 motors, with given polarity of fields and brushes, and corresponding direction of car motion (P. S. Ry.).



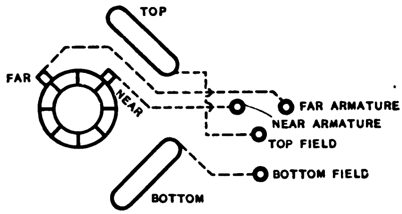
Notes.—Facing commutator, motor terminals come out on right-hand side of motor. Far or left-hand armature out of left top hole. Near or right-hand armature out of left bottom hole. Far or left-hand field out of right top hole. Near or right-hand field out of right bottom hole.

FIG. 26.—Order observed in bringing out motor terminals on Westinghouse 68 motor (P. S. Ry.).



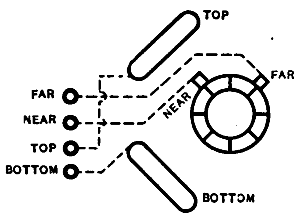
Notes.—Face commutator end when looking at armature connections. Face bushings when considering them. Far armature out of the top hole. Near armature out of the second hole. Top field out of the third hole. Bottom field out of the bottom hole.

FIG. 27.—Order of bringing out motor terminals of GE-57, 67, 80-C, 52, 58, 1000 and 800 motors, on the right-hand side, when armature terminal bushings are vertical (P. S. Ry.).



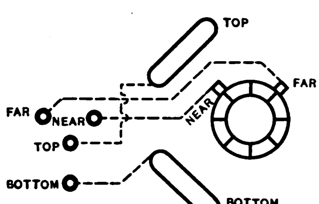
Notes.—Face commutator end when looking at armature connections. Face bushings when considering them. Far armature out of top right-hand hole. Near armature out of top left-hand hole. Top field out of third hole. Bottom field out of bottom hole.

Fig. 28.—Order of bringing out motor terminals of GE-57, 67, 80-C, 52, 58, 1000 and 800 motors, on the right-hand side, when armature terminal bushings are horizontal (P. S. Ry.).



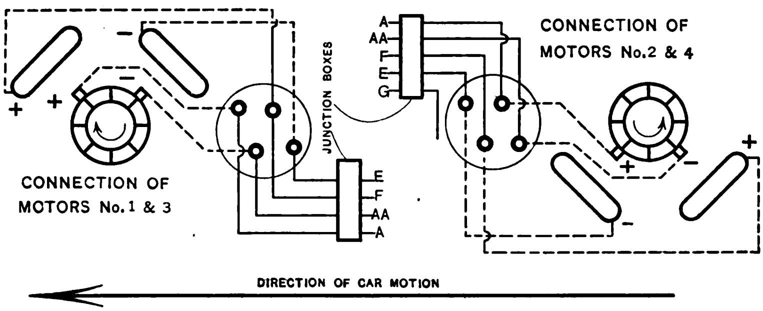
Notes.—Face commutator end when looking at armature connections. Face bushings when considering them. Far armature out of top hole. Near armature out of second hole. Top field out of third hole. Bottom field out of bottom hole.

Fig. 29.—Order of bringing out motor terminals of GE-57, 67, 52, 58, 80-C, 1000 and 800 motors, on the left-hand side, when armature terminal bushings are vertical (P. S. Ry.).



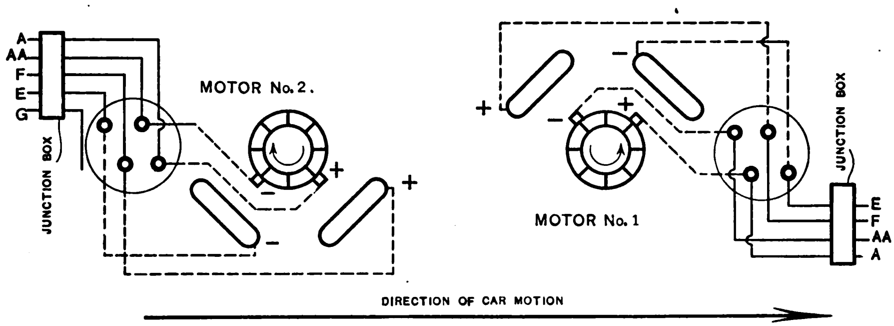
Notes.—Face commutator end when looking at armature connections. Face bushings when considering them. Far armature out of left-hand hole. Near armature out of right-hand hole. Top field out of third hole. Bottom field out of bottom hole.

Fig. 30.—Order of bringing out motor terminals of GE-57, 67, 80-C, 58, 52, 1000 and 800 motors, on the left-hand side, when armature terminal bushings are horizontal (P. S. Ry.).



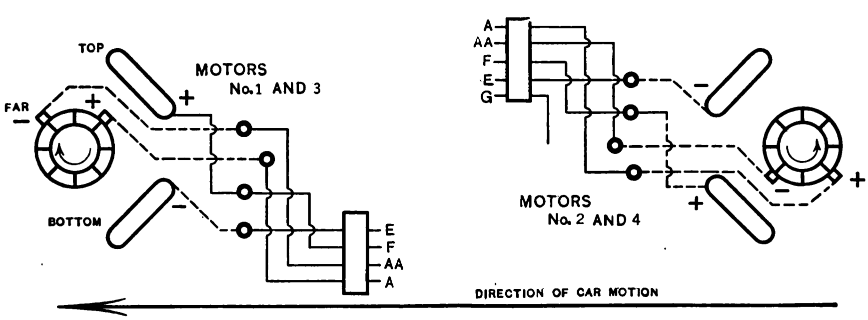
Notes.—On all motor fields, run straight. On motors 1 and 3, armatures run straight. On motors 2 and 4, armatures crossed between spreader and junction boxes. Where no spreader is used, Nos. 2 and 4 armatures are crossed between motor and junction box. Ground wires on motors 2 and 4 only.

FIG. 31.—Connections for four Westinghouse 68 motors hung outside of axle on double-truck car (P. S. Ry.).



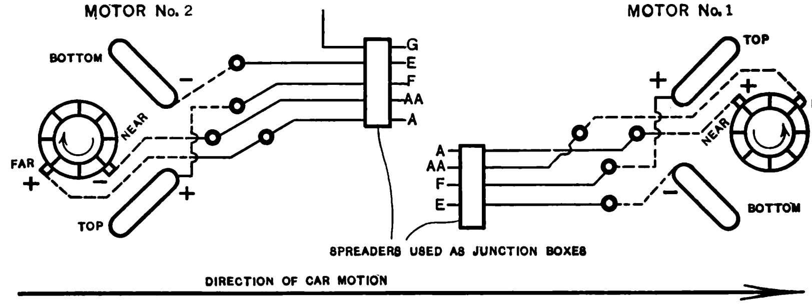
Notes.—No. 1 connects same as No. 2 on a four-motor car. No. 2 connects same as No. 1 on a four-motor car. No. 2. armature and fields straight; No. 1 armature crossed.

FIG. 32.—Connections for two Westinghouse 68 motors on single-truck car (P. S. Ry.).



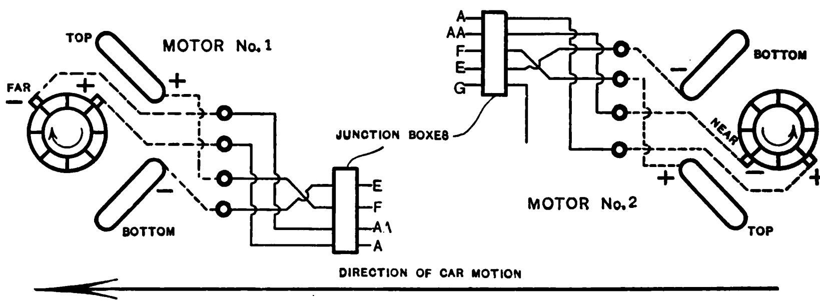
Notes.—Armature wires on motors Nos. 1 and 3 crossed between junction box and spreader. All other motor wires straight.

FIG. 33.—Connections of four GE motors (except Nos. 57 and 1000) hung outside of axles on two double trucks. Terminals on axle side (P. S. Ry.).



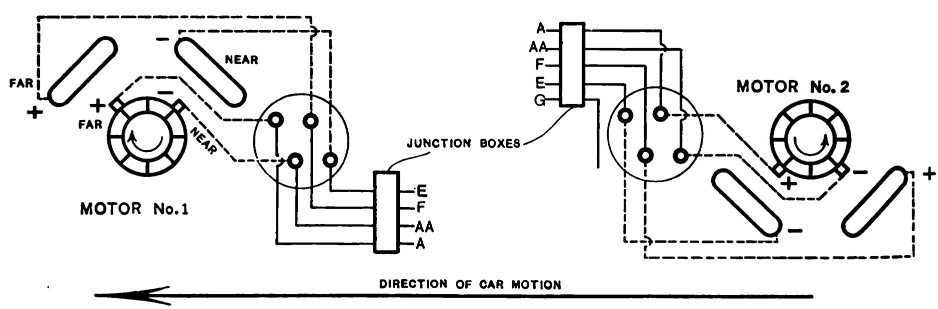
Notes.—Facing commutator end, motor terminals come out on left or suspension side of motors. Facing spreader, single A to the right.

FIG. 34.—Connections of two GE motors (except Nos. 57 and 1000) on a single truck (P. S. Ry.).



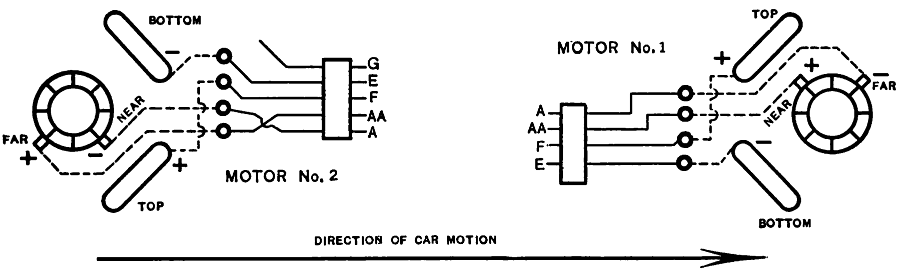
Notes.—No. 1 armatures crossed between motor or spreader and junction box. All other motor wires run straight.

FIG. 35.—Connections of two GE motors (except Nos. 57 and 1000) on double trucks. Mounted as in Fig. 18, motor terminals out on axle side (P. S. Ry.).



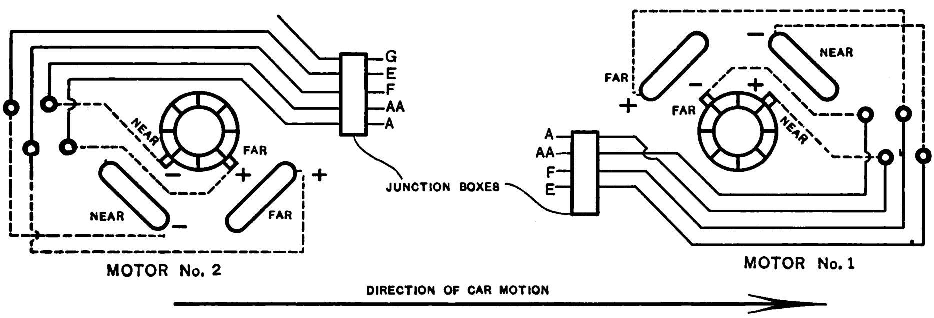
Notes.—No. 2 armatures crossed between motor or spreader and junction box. All other motor wires run straight.

FIG. 36.—Connections of two Westinghouse 68 motors on two double trucks mounted as in Fig. 18, motor terminals out on axle side (P. S. Ry.).



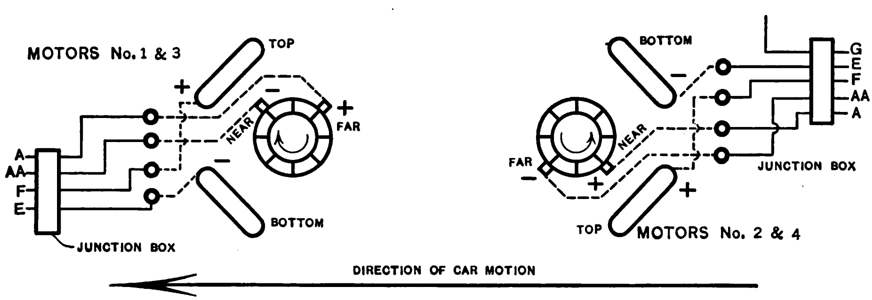
Notes.—No. 1 armatures crossed between motor or spreader and junction box. All other motor wires run straight.

Fig. 37.—Connections of two GE motors (except Nos. 57 and 1000) mounted on double trucks as in Figs. 18 and 19. Motor terminals out on suspension side (P. S. Ry.).



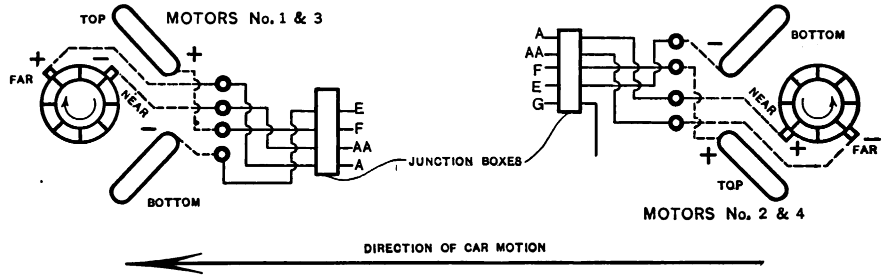
Notes.—No. 1 armatures crossed between motor or spreader and junction box. All other motor wires run straight.

Fig. 38.—Connections of two Westinghouse 68 motors, mounted on double trucks as in Figs. 18 and 19. Junction box on axle side (P. S. Ry.).



Notes.—Terminals out on suspension side. Armature wires of motors 2 and 4 crossed. All other motor wires run straight.

Fig. 39.—Connections of four GE-1000 on 57 motors (P. S. Ry.).



Notes.—Terminals out on axle side armature wires of motors 2 and 4 crossed. All other motor wires run straight.

Fig. 40.—Connections of four GE-1000 or 57 motors (P. S. Ry.).

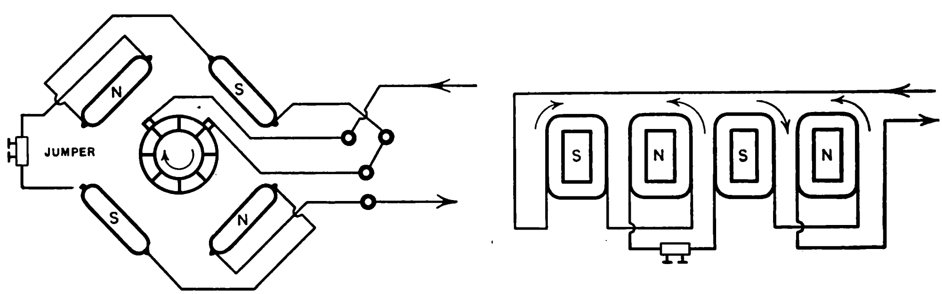


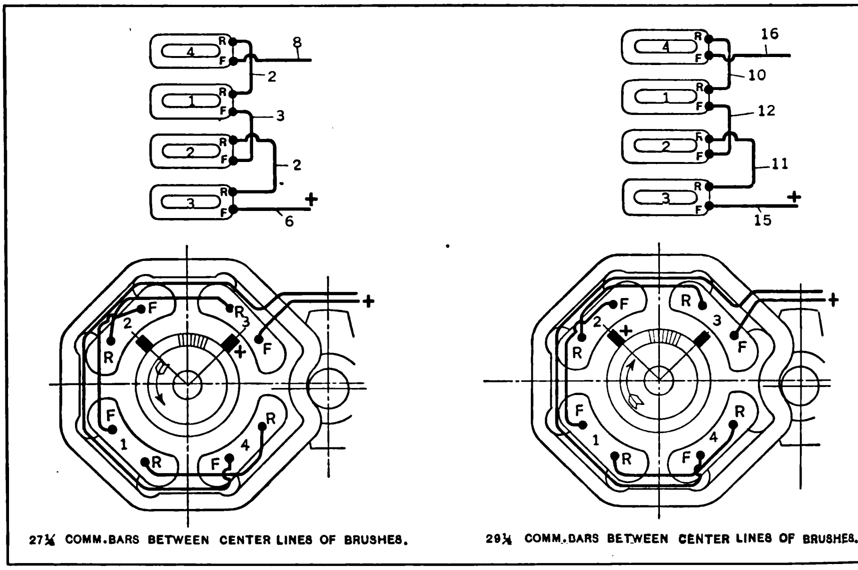
Fig. 41.—Westinghouse 68 field connections outside jumper (P. S. Ry.).

LEAD NO.	TYPE OF MOTOR	LENGTH OF LEAD	SIZE OF WIRE
1	West. 101 G.E. 80	0′-11″	T. D. 5-2
2	West. 68	0′-18″	”
3	West. 68	0′-22″	”
4	G.E. 80	3′-0″	”
5	G.E. 80	3′-10″	”
6	West. 68	4′-10″	”
7	West. 101	5′-5″	”
8	West. 68	5′-10″	”
9	West. 101	6′-9″	”
10	West. 81 G.E. 57	0′-18″	T. D. 3-2
11	West. 81 West. 93	0′-20″	”
12	West. 81 G.E. 57	2′-2″	”
13	West. 93	3′-8″	”
14	West. 93	4′-2″	”
15	West. 81 G.E. 57	5′-10″	”
16	West. 81 West. 93	7′-2″	”
17	G.E. 64 G.E. 64	0′-18″	T. D. 1-2
18	G.E. 64	3′-3″	”
19	G.E. 64	4′-7″	”

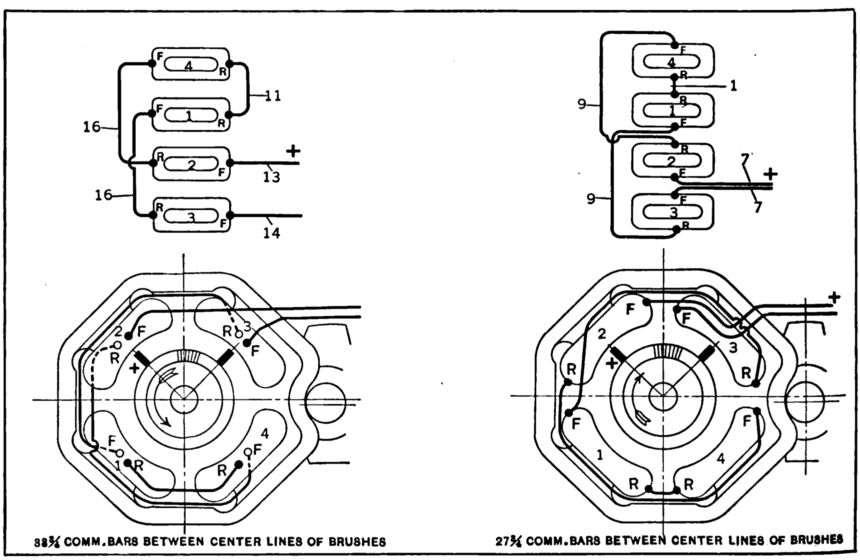
Fig. 42.—Field lead lengths (B. R. T.). Numbers in first column refer to the numbered leads on following diagrams. For "T. D." wires see table below.

B. R. T. RUBBER INSULATED WIRES AND CABLES

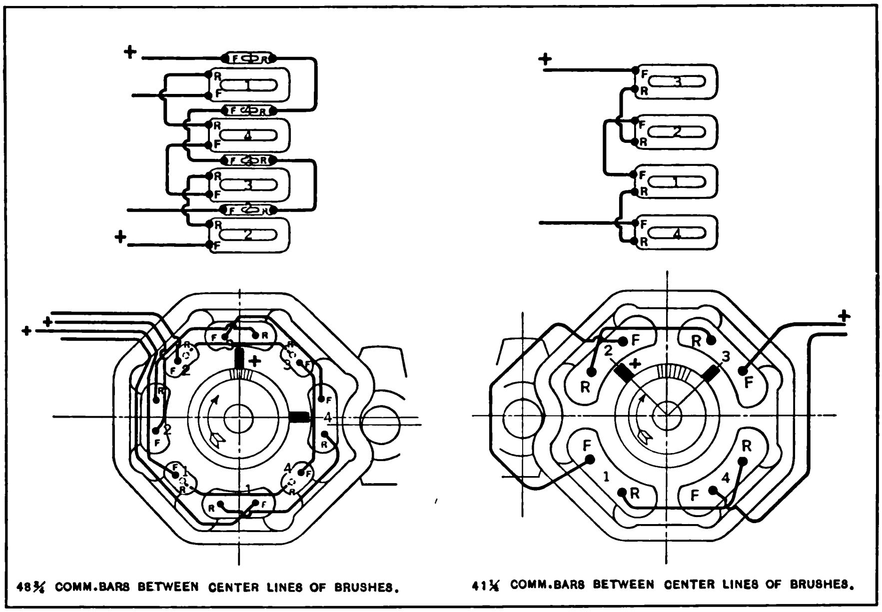
	T. D. 1–2	T. D. 3–2	T. D. 5–2
Approximate size B. & S.	1	3	5
Number of wires	210	259	133
Size wire B. & S.	24	27	26
Number of strands	30	37	19
Wires per strand	7	7	7
Area in circular mils	84,840	52,188	33,795
Rubber wall	$\frac{6}{64}$	$\frac{5}{64}$	$\frac{4}{64}$
Diameter rubbers—32nds	$18\frac{1}{2}$	$14\frac{1}{2}$	12
Number of braids	3	3	3
Diameter over braids—32nds	$24\frac{1}{2}$	20	18
Voltage test	6,000	5,000	3,000
Megohms per mile	1,200	1,250	1,150



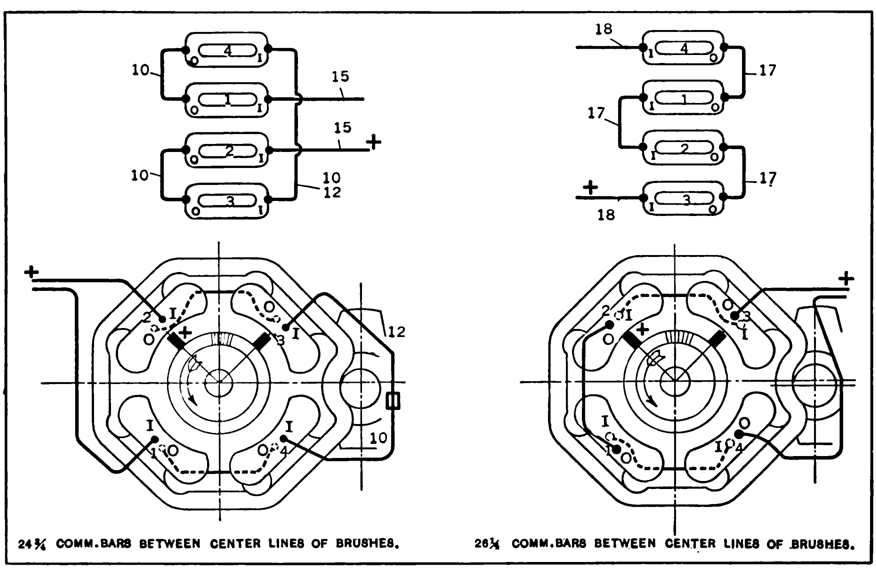
FIGS. 43 AND 44.—Diagrams of field leads and spacing of brushes, Westinghouse 68 and 81 motors (B. R. T.).



FIGS. 45 AND 46.—Diagrams of field leads and spacing of brushes, Westinghouse 93 and 101 motors (B. R. T.).



FIGS. 47 AND 48.—Diagrams of field leads and brush spacings of Westinghouse 300 and 50-B, E and L motors (B. R. T.).



FIGS. 49 AND 50.—Diagrams of field leads and spacing of brushes, GE-57 and 64 motors (B. R. T.).

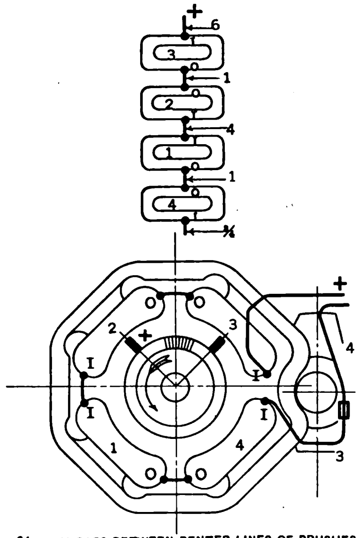


FIG. 51.—Diagram of field leads and brush spacing, GE-80. Motor (B. R. T.).

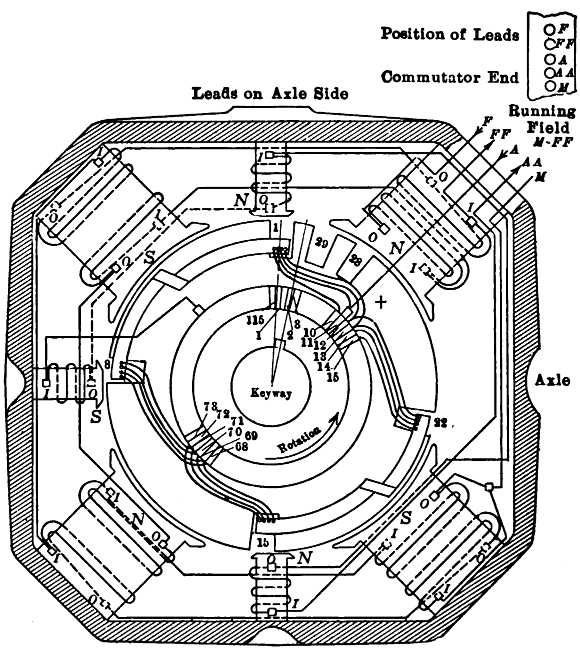


FIG. 52.—General Electric 234 motor, showing direction of rotation, throw of leads, three-turn armature, and method of bringing out leads.

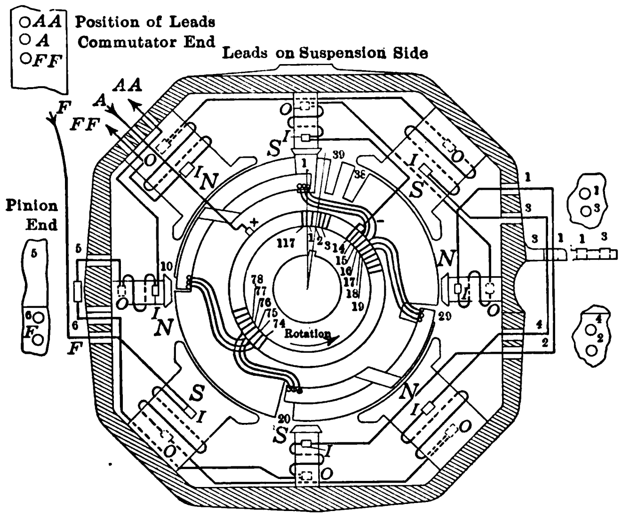


FIG. 53.—General Electric 200-A motor, showing direction of rotation, throw of leads, four-turn armature and method of bringing out leads.

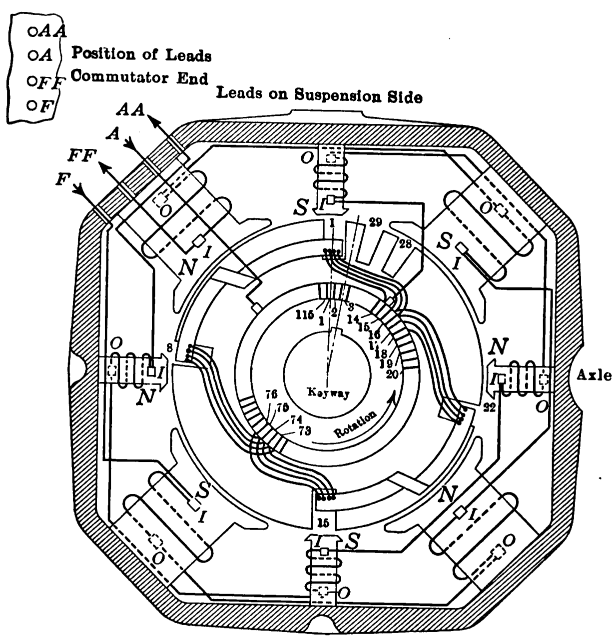


FIG. 54.—General Electric 201-G motor, showing direction of rotation, throw of leads, three-turn armature and method of bringing out leads.

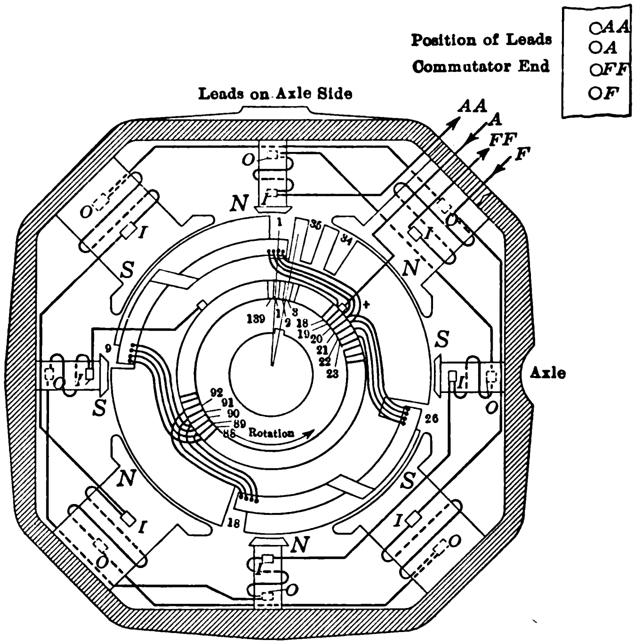


FIG. 55.—General Electric 203-C and L motor, showing direction of rotation, throw of leads, three-turn armature and method of bringing out leads.

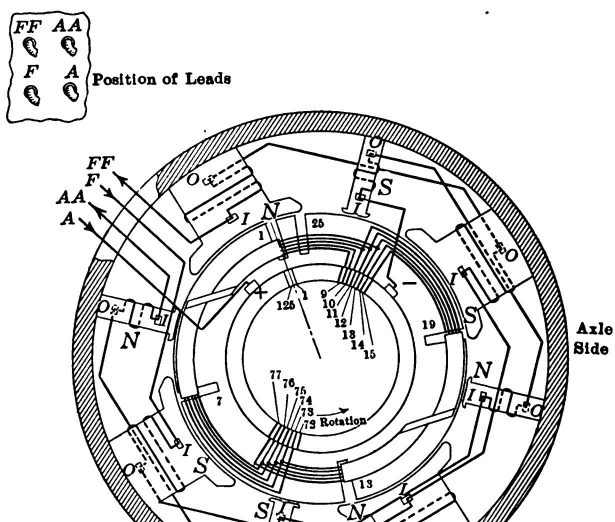


FIG. 56.—General Electric 216 motor, showing direction of rotation, throw of leads, three-turn armature and method of bringing out leads.

Fig. 57.—MOTOR RESISTANCES

Type	Resistance in ohms at 25° C.		
	Armature	Field	Total
Westinghouse 68	0.230	0.275	0.505
Westinghouse 81	0.124	0.147	0.271
Westinghouse 93	0.140	0.158	0.298
Westinghouse 93-A$_2$	0.140	0.158	0.298
Westinghouse 101	0.242	0.247	0.489
Westinghouse 50-B	0.0374	0.034	0.0714
Westinghouse 50-E	0.0374	0.034	0.0714
Westinghouse 50-L	0.0374	0.034	0.0714
Westinghouse 300	0.035	Main 0.173	0.0657
		Aux. 0.0134	
General Electric 64	0.182	0.222	0.404
General Electric 80	0.296	0.278	0.574
General Electric 800	0.2397	0.6248	0.8645

Fig. 58.—WESTINGHOUSE GRID RESISTORS FOR STANDARD TWO MOTOR CAR EQUIPMENTS

Motors				Weight of car in tons loaded	Wheel dia.	Type of controller	Resistor—8″—3 point type				
Type	Voltage	H.p.	Gear ratio				Style No.	Frames	Grids per frame	Net wt.	Ohms
12-A	500	25	14:68	8.5–10.0	33″	K-10-A, H.	58871-A	2	18	180	5.20
12-A	500	30	14:68	8.0– 9.5	33″	K-10-A, H.	58871-A	2	18	180	5.20
92-A	500	35	15:69	11.0–12.5	33″	K-10-A, H.	55137	2	18	180	4.56
92-A	500	35	18:66	10.0–11.5	33″	K-10-A, H.	55137	2	18	180	4.56
101-B$_2$	500	40	15:69	13.0–15.0	33″	K-10-A, H, or K-11-A,H,K-36-B,C.	55137	2	18	180	4.56
101-B$_2$	500	40	18:66	11.0–13.0	33″	K-10-A, H, or K-11-A,H,K-36-B,C.	55137	2	18	180	4.56
307	500	40	14:70	14.0–16.0	33″	K-36-B, C, or K-11-A,H-K-27-A.	55137	2	18	180	4.56
307	500	40	15:69	13.0–15.0	33″	K–36-B, C, or K–11-A, H-K-27-A.	55137	2	18	180	4.56
306	500	50	14:70	14.0–16.0	33″	K-36-B, C, or K-11-A, H-K-27-A.	55139	2	18	180	3.80
306	500	50	15:69	13.0–15.0	33″	K-36-B, C, or K-11-A, H-K-27-A.	55139	2	18	180	3.80
101-D$_2$	500	50	15:69	14.0–16.0	33″	K-11-A, H, or K-36-B, C-K-27-A.	55139	2	18	180	3.80
101-D$_2$	500	50	18:66	14.0–16.0	33″	K-11-A, H, or K-36-B, C-K-27-A.	55143	2	25	250	3.13
93-A$_2$	500	60	16:71	20.0–23.0	33″	K-11-A, H, or K-36-B, C-K-27-A.	55143	2	25	250	3.13
93-A$_2$	500	60	19:68	1.70–19.0	33″	K-11-A, H, or K-36-B, C-K-27-A.	55143	2	25	250	3.13
305	500	60	16:71	20.0–23.0	33″	K-35-G, H, or	108372	1	14	350	3.18
						K-40-A, K-43-A, B.		2	28		
305	500	60	18:69	19.0–22.0	33″	K-35-G, H, or	108478	1	15	385	2.95
						K-40-A, K-43-A, B.		2	31		
310	600	75	15:69	23.0–26.0	33″	K-36-B, C, or K-11-A, K-27-A.	138767	3	22	330	3.60

Fig. 58.—WESTINGHOUSE GRID RESISTORS FOR STANDARD TWO MOTOR CAR EQUIPMENTS —*Continued*

Motors				Weight of car in tons loaded	Wheel dia.	Type of controller	Resistor—8″—3 point type				
Type	Volt-age	H.p.	Gear ratio				Style No.	Frames	Grids per frame	Net wt.	Ohms
112-B	500	75	16:73	22.0–25.0	33″	K-6-A, H, or K-29-A.	55151	3	25	375	2.64
112-B	500	75	16:73	22.0–25.0	33″	K-28-B, F.	83372	3	25	375	2.60
112-B	500	75	16:73	21.0–24.0	33″	K-35-G, H, or K-40-A, K-43-A, B.	108478	1 2	15 31	385	2.95
304	500	75	16:71	21.0–24.0	33″	K-35-G, H, or K-40-A, K-43-A, B.	108478	1 2	15 31	385	2.95
304	600	90	18:69	21.0–24.0	33″	K-35-G, H, or K-40-A, K-43-A, B.	108478	1 2	15 31	385	2.95
121-A	550	90	17:58	25.0–28.0	33″	K-35-G, H, or K-40-A, K-43-A, B.	139924	1 2	10 34	390	2.08
121-A	550	90	20:55	23.0–26.0	33″	K-35-G, H, or K-40 A, K-43-A, B.	139924	1 2	10 34	390	2.08
303-A	550	100	16:61	27.0–30.0	33″	K-35-G, H, or K-40-A, K-43 A, B.	136263	1 2	20 30	400	1.95
303-A	550	100	20:57	25.0–28.0	33″	K-35-G, H, or K-40-A, K-43-A, B.	136263	1 2	20 30	400	1.95
303-A	600	115	24:53	24.0–27.0	33″	K-35-G, H, or K-40-A, K-43-A, B.	136263	1 2	20 30	400	1.95

Note.—Where two sub-letters in any controller type designation are listed, the second indicates the controller which operates the auxiliary contactor.

In selecting resistors for gear ratios not listed, note that with a given resistance, a lower speed gear ratio is accompanied by a corresponding increase in car weight and vice versa.

Fig. 59.—WESTINGHOUSE GRID RESISTORS FOR STANDARD FOUR MOTOR CAR EQUIPMENTS.

Motors				Weight of car in tons loaded	Wheel dia.	Type of controller	Resistors—8″—3 point type				
Type	Volt-age	H.p.	Gear ratio				Style No.	Frames	Grids yer frame	Net wt.	Ohms
12-A	500	25	14:68	13.5–15.0	33″	K-12-A, D.	55139	2	18	180	3.80
12-A	500	30	14:68	14.0–16.0	33″	K-12-A, D.	55143	2	25	250	3.13
92-A	500	35	15:69	20.0–23.0	33″	K-28-B, F.	83372	3	25	375	2.60
92-A	500	35	18:66	17.0–20.0	33″	K-28-B, F.	83372	3	25	375	2.60
101-B_2	500	40	15:69	23.0–26.0	33″	K-28-B, F.	83372	3	25	375	2.60
101-B_2	500	40	18:66	20.0–23.0	33″	K-28-B, F.	83372	3	25	375	2.60
101-B_2	500	40	18:66	20.0–23.0	33″	K-6-A, H, or K-29-A.	55151	3	25	375	2.64
307	500	40	15:69	20.0–23.0	33″	K-35-G, H, or K-40-A.	108478	1 2	15 31	385	2.95
307	500	40	18:66	18.0–21.0	33″	K-35-G, H, or K-40-A.	108478	1 2	15 31	385	2.95
306	500	50	15:69	27.0–30.0	33″	K-35-G, H, or K-40-A.	139924	1 2	10 34	390	2.08
306	500	50	18:66	25.0–28.0	33″	K-35-G, H, or K-40-A.	139924	1 2	10 34	390	2.08
101-D_2	500	50	18:66	24.0–27.0	33″	K-35-G, H, or K-40-A.	139924	1 2	10 34	390	2.08

Fig. 59.—WESTINGHOUSE GRID RESISTORS FOR STANDARD FOUR MOTOR CAR EQUIPMENTS.—*Continued*

Motors				Weight of car in tons loaded	Wheel dia.	Type of controller	Resistor—8″—3 point type				
Type	Volt-age	H.p.	Gear ratio				Style No.	Frames	Grids per frame	Net wt.	Ohms
101-D_2	500	50	22:62	23.0–26.0	33″	K-35-G, H, or K-40-A.	136263	1 2	20 30	400	1.95
101-D_2	500	50	15:69	22.0–25.0	33″	K-14-A, E.	55151	3	25	375	2.64
93-A_2	500	60	19:68	30.0–34.0	33″	K-34-D, F.	110350	1 4	20 30	700	2.02
93-A_2	500	60	24:63	26.0–29.0	33″	K-34-D, F.	110350	1 4	20 30	700	2.02
305	500	60	18:69	32.0–36.0	33″	K-34-D, F.	110350	1 4	20 30	700	2.02
305	500	60	21:66	30.0–34.0	33″	K-34-D, F.	110350	1 4	20 30	700	2.02
112-B	500	75	19:70	30.0–34.0	33″	K-34-D, F.	136264	7	22	770	1.74
112-B	500	75	20:69	30.0–34.0	33″	K-34-D, F.	136264	7	22	770	1.74
304	500	75	18:69	34.0–38.0	33″	K-34-D, F.	136264	7	22	770	1.74
304	500	75	21:66	30.0–34.0	33″	K-34-D, F.	136264	7	22	770	1.74
121-A	550	90	17:58	37.0–41.0	33″	K-34-D, F.	136265	6	28	840	1.48
121-A	550	90	20:55	35.0–39.0	33″	K-34-D, F.	136265	6	28	840	1.48

Note.—Where two sub-letters in any controller type designation are listed, the second indicates the controller which operates the auxiliary contactor.

In selecting resistors for gear ratios not listed, note that with a given resistance, a lower speed gear ratio is accompanied by a corresponding increase in car weight and vice versa.

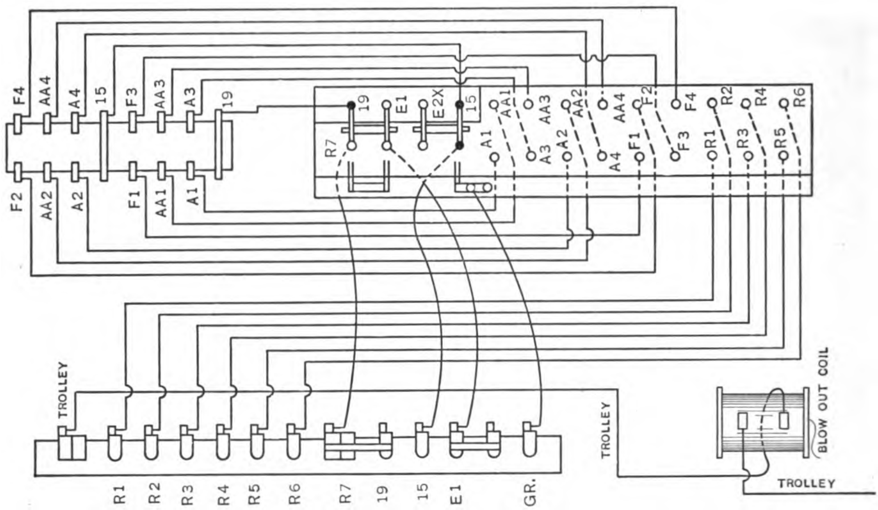


FIG. 61.—Wiring diagram for K-6 controller (P. S. Ry.).

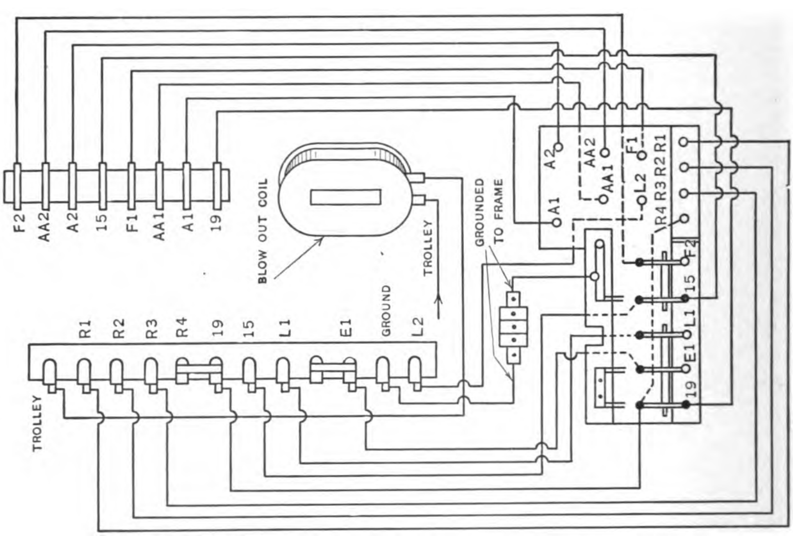


FIG. 60.—Wiring diagram for K-12 controller (P. S. Ry.).

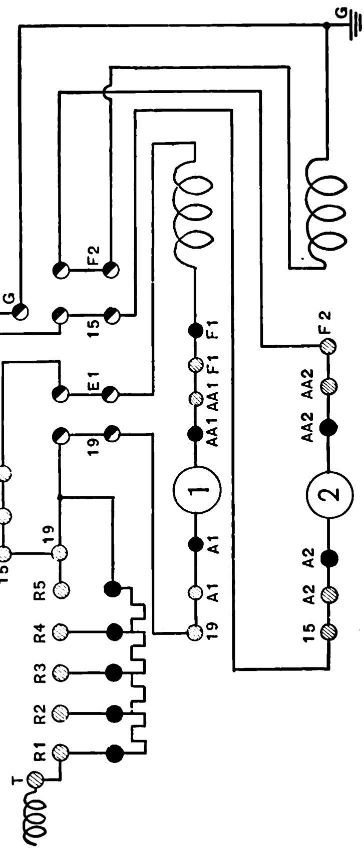


FIG. 63.—Circuit diagram for K-11 controller (C. W. Squier).

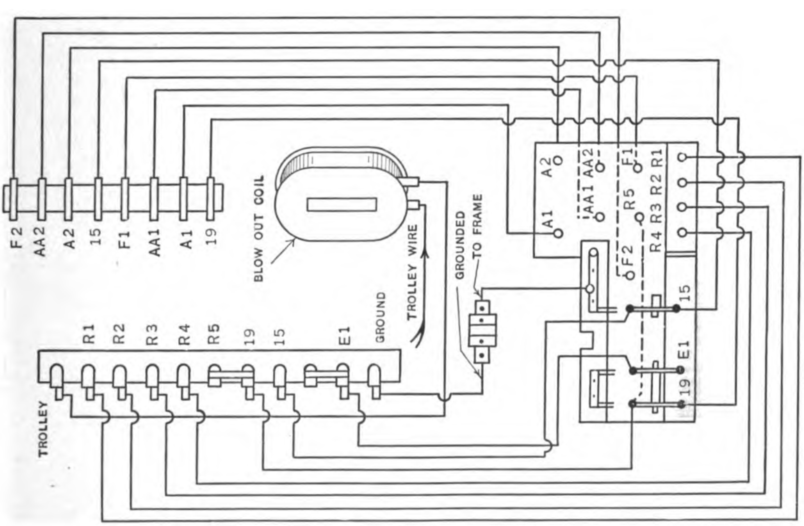


FIG. 62.—Wiring diagram for K-11 controller (B. R. T.).

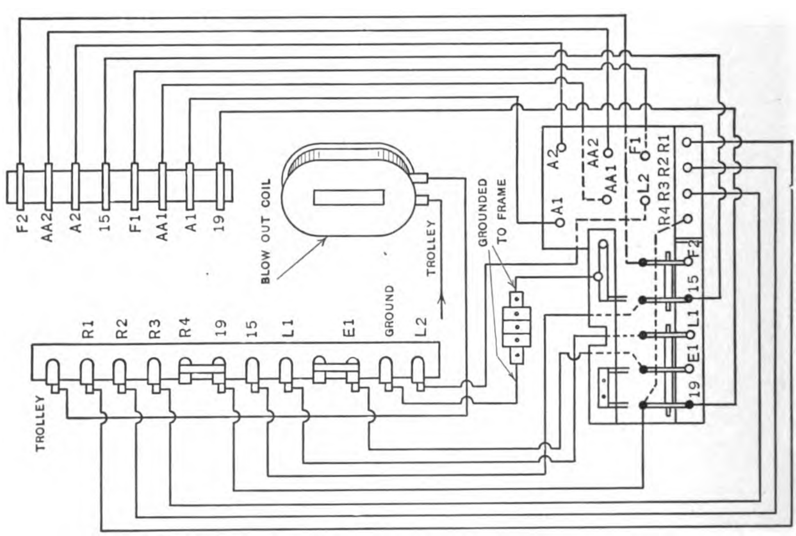


FIG. 60.—Wiring diagram for K-12 controller (P. S. Ry.).

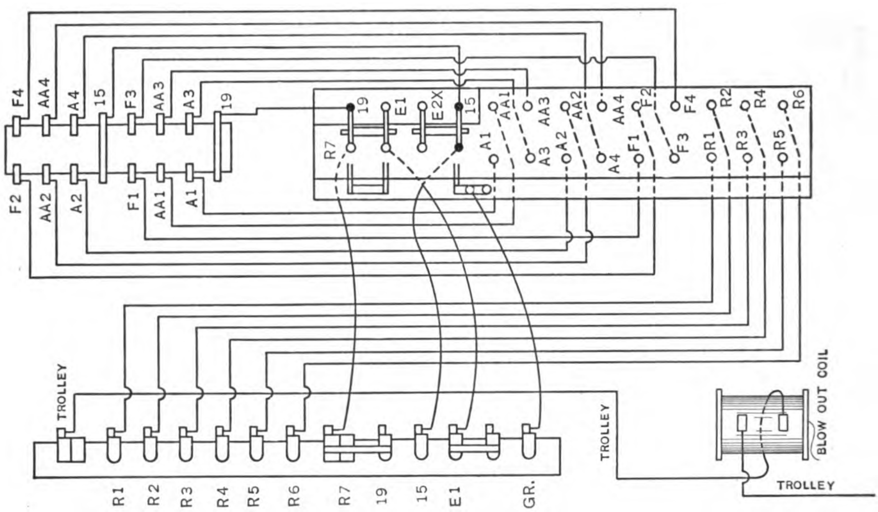


FIG. 61.—Wiring diagram for K-6 controller (P. S. Ry.).

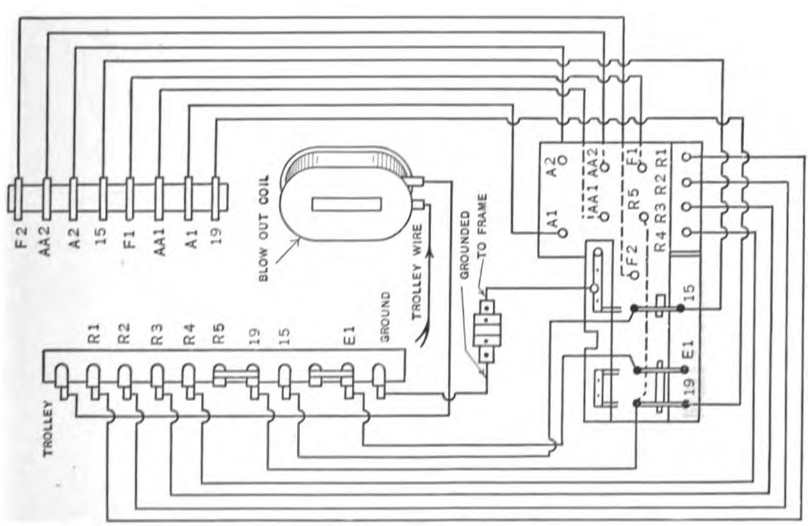


FIG. 62.—Wiring diagram for K-11 controller (B. R. T.).

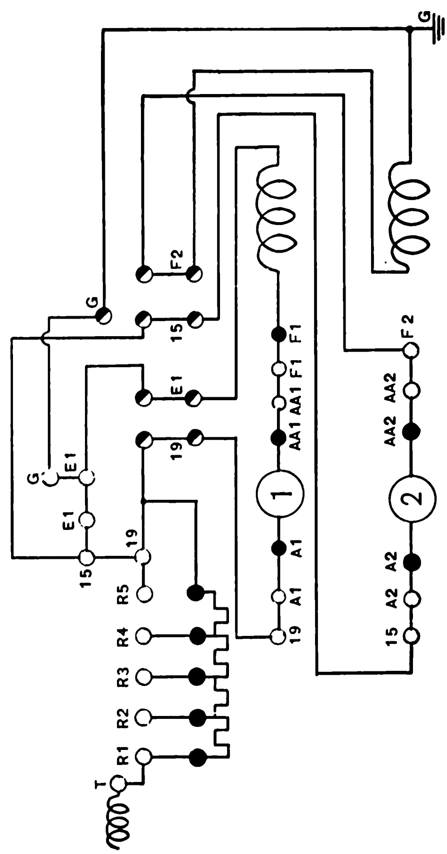


FIG. 63.—Circuit diagram for K-11 controller (C. W. Squier).

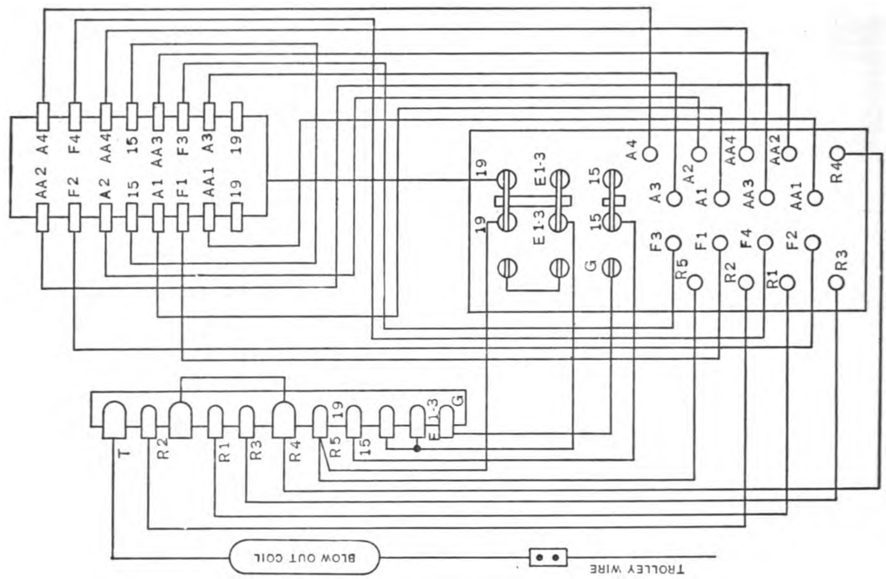


FIG. 65.—Wiring diagram for K-28-B controller (B. R. T.).

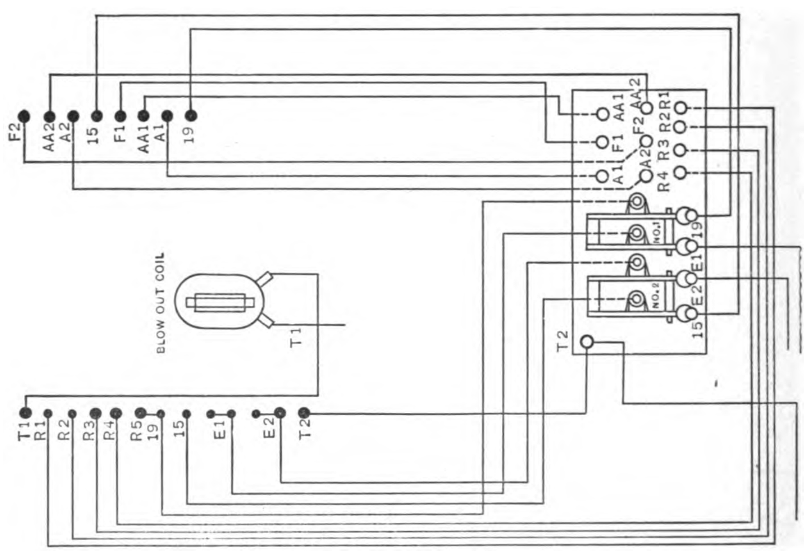


FIG. 64.—Wiring diagram for K-27 controller (B. R. T.).

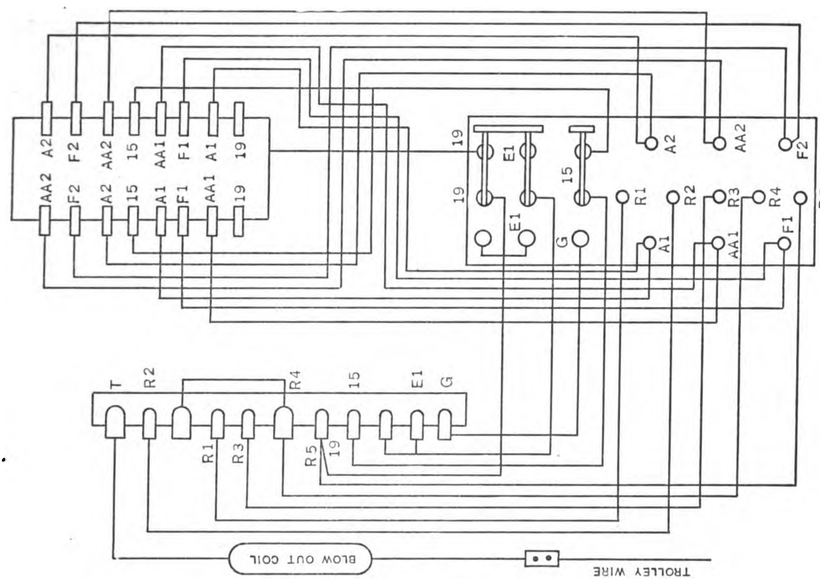


FIG. 67.—Wiring diagram for K-28-L controller (B. R. T.).

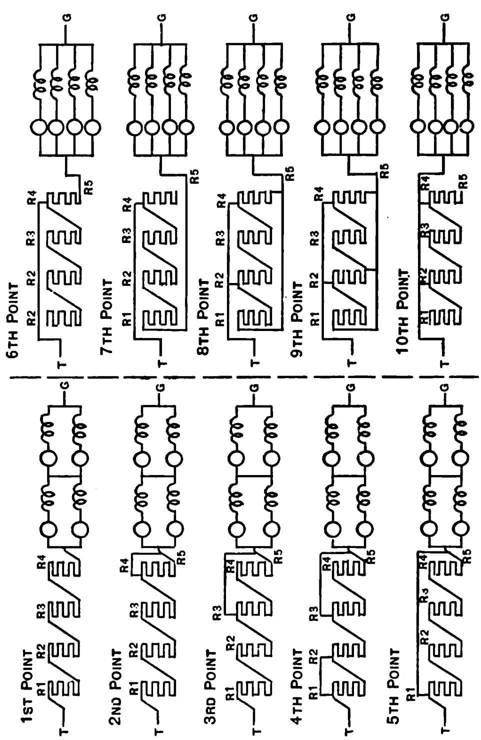


FIG. 66.—Circuit diagram of K-28-B controller (C. W. Squier).

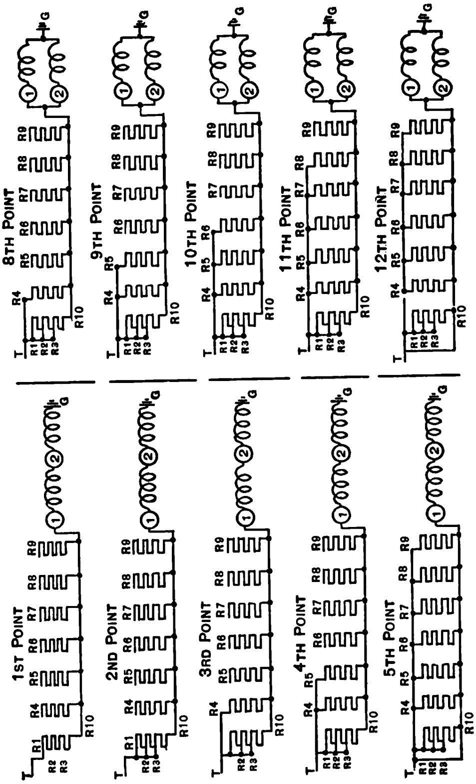


FIG. 69.—Circuit diagram of Westinghouse 131 controller (C. W. Squier).

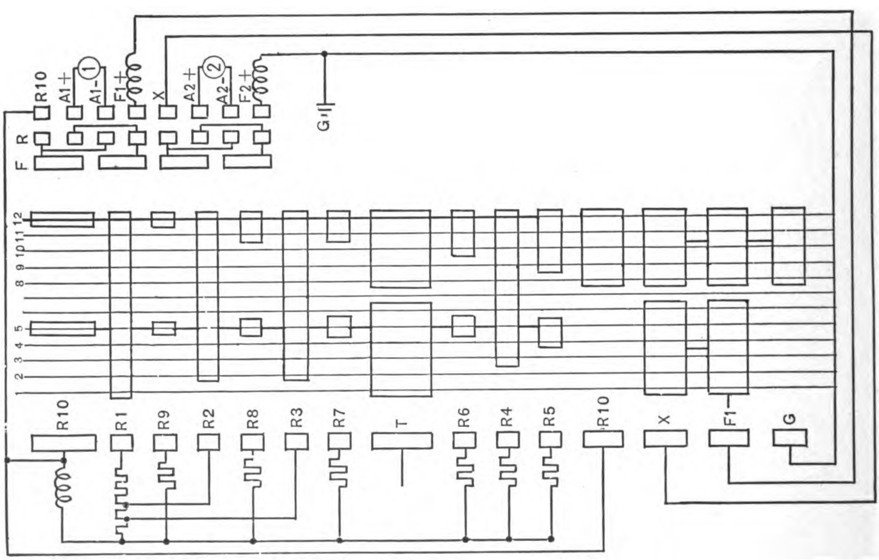


FIG. 68.—Wiring diagram for Westinghouse No. 131 controller (C. W. Squier).

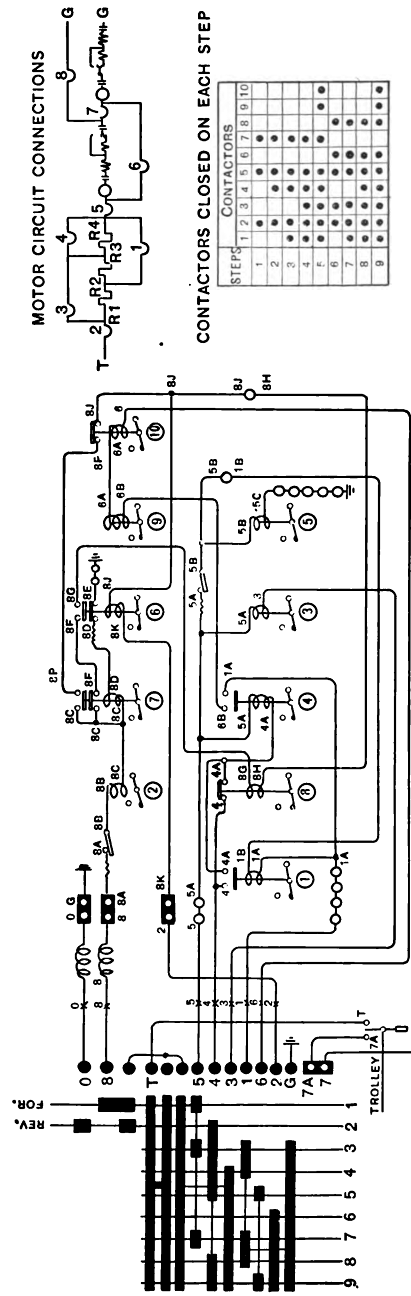
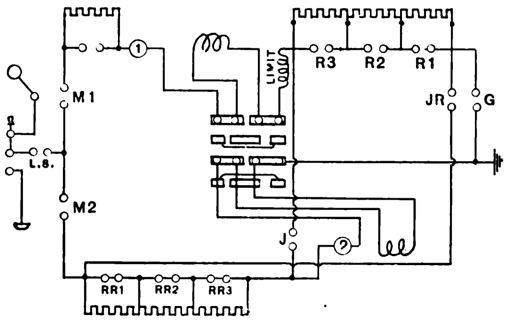


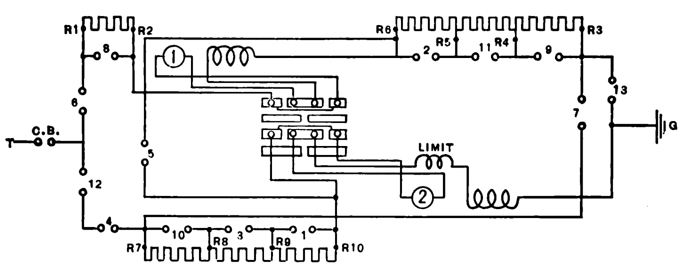
FIG. 70.—Simplified circuit diagram and sequence of switches for C-96-A master · controller with type M control (C. W. Squier).

CONTROL FOR TYPE 1400 CARS



POINT	SWITCHES												
1st	L.S.	M1				JR							
2nd	L.S.	M1	S			JR							
3rd	L.S.	M1	S			JR	RR1						
4th	L.S.	M1	S			JR	RR1	R1					
5th	L.S.	M1	S			JR	RR1	R1	RR2				
6th	L.S.	M1	S			JR	RR1	R1	RR2	R2			
7th	L.S.	M1	S			JR	RR1	R1	RR2	R2	RR3		
8th	L.S.	M1	S			JR	RR1	R1	RR2	R2	RR3	R3	
Trans.	L.S.	M1	S			JR	RR1	R1	RR2	R2	RR3	R3	J
Trans.	L.S.	M1	S										J
Trans.	L.S.	M1	S	M2	G								J
9th	L.S.	M1	S	M2	G								
10th	L.S.	M1	S	M2	G		RR1	R1					
11th	L.S.	M1	S	M2	G		RR1	R1	RR2	R2			
12th	L.S.	M1	S	M2	G		RR1	R1	RR2	R2	RR3	R3	

Fig. 71.—Circuit diagram and sequence of switches B. R. T. type 1400 Cars with Westinghouse 251-I-3 control (C. W. Squier).



ON 1300 SERIES CARS, SWITCHES Nos. 9 & 10 COME IN AT SAME TIME AS No. 8.

POINT	SWITCHES													
1st	C.B.	6	7											
2nd	C.B.	6	7	8										
3rd	C.B.	6	7	8	9	10								
4th	C.B.	6	7	8	9	10	11	3						
5th	C.B.	6	7	8	9	10	11	3	1	2				
Trans.	C.B.	6	7	8	9	10	11	3	1	2	5			
Trans.	C.B.	6		8							5			
Trans.	C.B.	6		8							5	12	4	13
6th	C.B.	6		8								12	4	13
7th	C.B.	6		8	9	10						12	4	13
8th	C.B.	6		8	9	10	11	3				12	4	13
9th	C.B.	6		8	9	10	11	3	1	2		12	4	13

Fig. 72.—Main motor circuit diagram and sequence of switches of turret control (C. W. Squier).

Cars with ... K-11 controllers, DT-11 resistance, GE-64 motors

Point	Resistance
1	5.75 to 6.20 ohms
2	3.70 to 4.20 ohms
3	2.30 to 2.70 ohms
4	1.60 to 2.00 ohms
5	1.00 to 1.40 ohms
6	3.05 to 3.40 ohms
7	1.60 to 1.95 ohms
8	.90 to 1.20 ohms
9	.30 to .70 ohms

Motors	
Armatures	.190 to .270
Fields	.215 to .300

Fig. 73.—Resistance limits for inspection test set (B. R. T.).

Cars with.... K-28-L controllers, DE-28 resistance, 93-A-2 motors

Point	Resistance
1	5.30 to 5.80 ohms
2	3.95 to 4.45 ohms
3	2.45 to 2.95 ohms
4	1.25 to 1.75 ohms
5	.95 to 1.45 ohms
6	1.65 to 1.95 ohms
7	1.25 to 1.55 ohms
8	.90 to 1.20 ohms
9	.50 to .75 ohms
10	.25 to .45 ohms

Motors	
Armatures	.150 to .225
Fields	.160 to .210

Fig. 74.—Resistance limits for inspection test set (B. R. T.).

Cars with.... K-11 controllers, K resistance, West.-93 motors

Point	Resistance
1	4.45 to 5.00 ohms
2	2.75 to 3.15 ohms
3	1.35 to 1.75 ohms
4	1.00 to 1.40 ohms
5	.80 to 1.15 ohms
6	2.20 to 2.50 ohms
7	.85 to 1.15 ohms
8	.45 to .85 ohms
9	.25 to .70 ohms

Motors	
Armatures	.220 to .240
Fields	.185 to .205

Fig. 75.—Resistance limits for inspection test set (B. R. T.).

Cars with.... K-11 controllers, DT-11 resistance, West.- 93 motors

Point	Resistance
1	5.30 to 5.75 ohms
2	3.30 to 3.75 ohms
3	2.00 to 2.40 ohms
4	1.35 to 1.75 ohms
5	.95 to 1.25 ohms
6	2.75 to 3.10 ohms
7	1.45 to 1.80 ohms
8	.80 to 1.10 ohms
9	.25 to .70 ohms

Motors	
Armatures	.220 to .240
Fields	.185 to .205

Fig. 76.—Resistance limits for inspection test set (B. R. T.).

Cars with.... K-11 controllers, K resistance, West.-81 motors

Point	Resistance
1	4.45 to 5.00 ohms
2	2.75 to 3.15 ohms
3	1.35 to 1.75 ohms
4	1.00 to 1.40 ohms
5	.80 to 1.15 ohms
6	2.20 to 2.50 ohms
7	.85 to 1.15 ohms
8	.45 to .85 ohms
9	.25 to .70 ohms
Motors	
Armatures	.150 to .250
Fields	.150 to .180

Fig. 77.—Resistance limits for inspection test set (B. R. T.).

Cars with.... K-11 controllers, DT-11 resistance, West.-81 motors

Point	Resistance
1	5.20 to 5.75 ohms
2	3.20 to 3.75 ohms
3	2.00 to 2.40 ohms
4	1.30 to 1.70 ohms
5	.80 to 1.20 ohms
6	2.65 to 3.10 ohms
7	1.40 to 1.80 ohms
8	.80 to 1.10 ohms
9	.25 to .70 ohms
Motors	
Armatures	.150 to .250
Fields	.150 to .180

Fig. 78.—Resistance limits for inspection test set (B. R. T.).

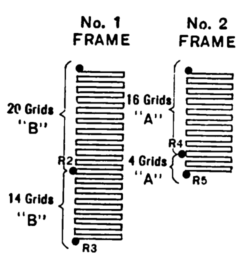


Fig. 79.—Lundie resistance used with K-11 controller (B. R. T.).

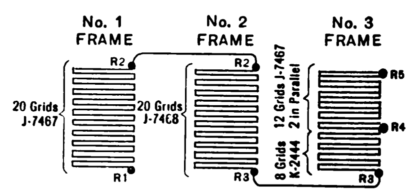
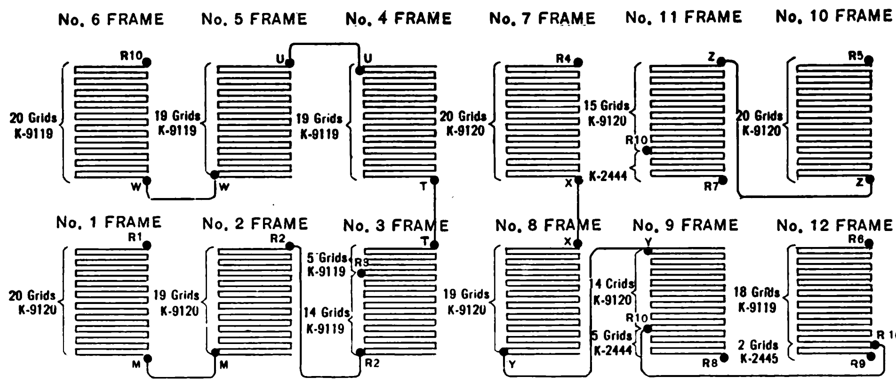


Fig. 80.—Westinghouse two-point suspension resistance used with K-11 controller and two motors (B. R. T.).



Note: Frames Nos. 2, 3, 4, 5, 8 and 9 have 20 grids each, but one of the end grids is made inactive by the placing of the terminal between grids.

FIG. 81.—Westinghouse two-point suspension resistance used with Nos. 131 and 160 controllers on elevated cars (B. R. T.).

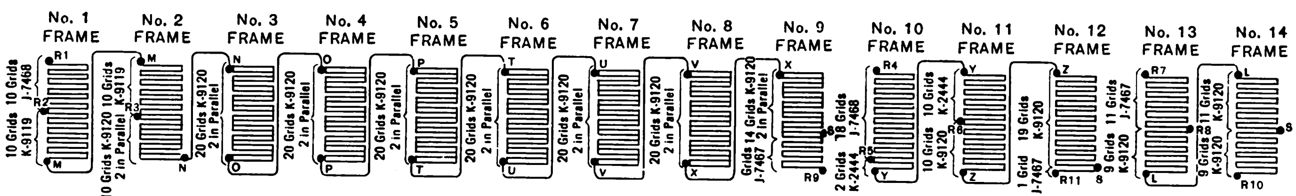


FIG. 82.—Westinghouse two-point suspension resistance used with L-2 controller and four motors on elevated cars (B. R. T.).

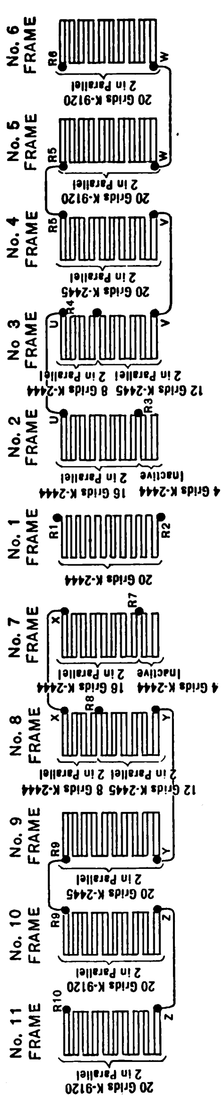


FIG. 83.—Westinghouse two-point suspension resistance used with turret controller on elevated car (B. R. T.).

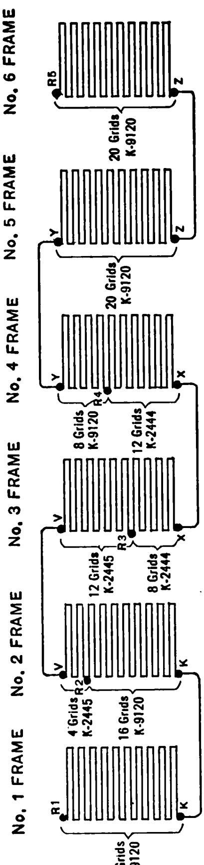


FIG. 84.—Westinghouse two-point resistance used with K-28-B controller and four motors (B. R. T.).

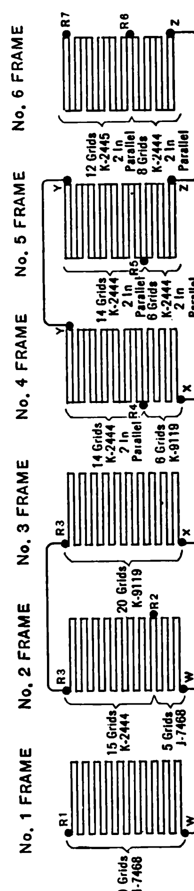


FIG. 85.—Westinghouse two-point suspension resistance used with K-6 controller and four motors (B. R. T.).

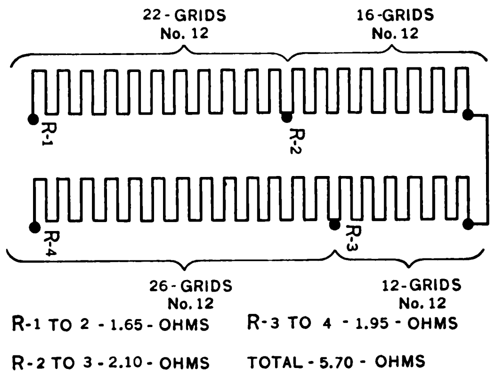


FIG. 86.—Arrangement of GE rheostat type R-G-A-2 on cars with type M control and two GE-234 motors (B. R. T.).

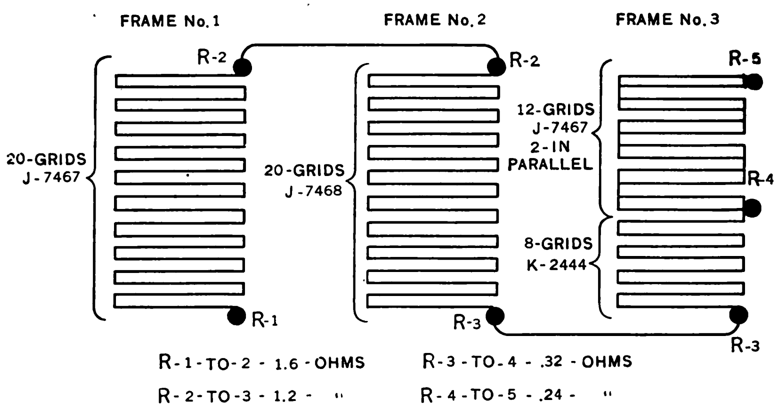


FIG. 87.—Arrangement of two-point suspension used with K-11 controllers and two motors (B. R. T.).

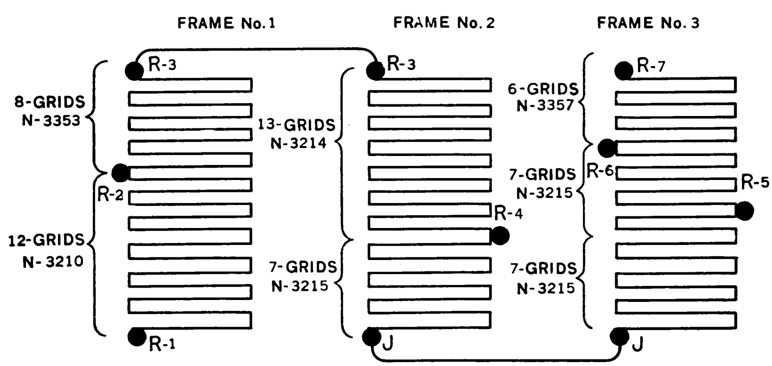


FIG. 88.—Arrangement of grids on work cars with K-6 controllers and four motors (B. R. T.).

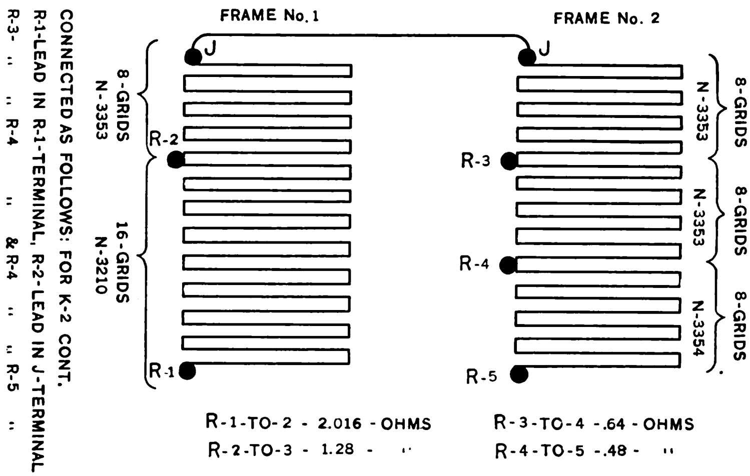


Fig. 89.—Arrangement of grids on cars with K-2, K-11 and K-27-A controllers and two motors (B. R. T.).

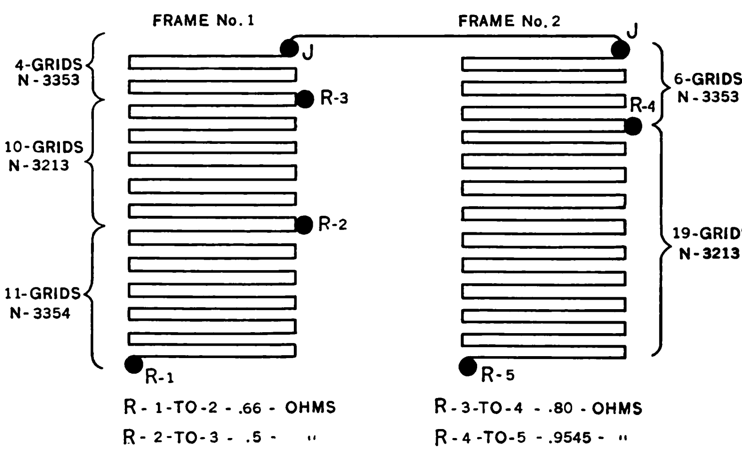


Fig. 90.—Arrangement of grids on cars with K-28-B controllers and four motors (B. R. T.).

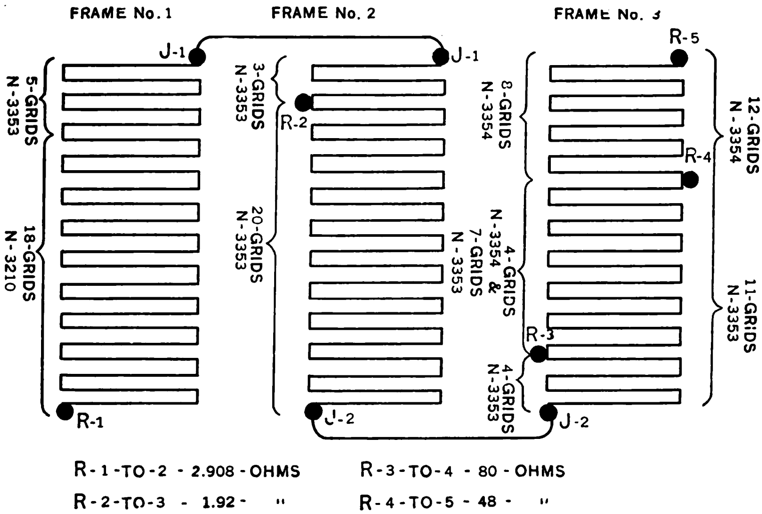


FIG. 91.—Arrangement of grids used on single-truck cars with K-11 controllers and two motors (B. R. T.).

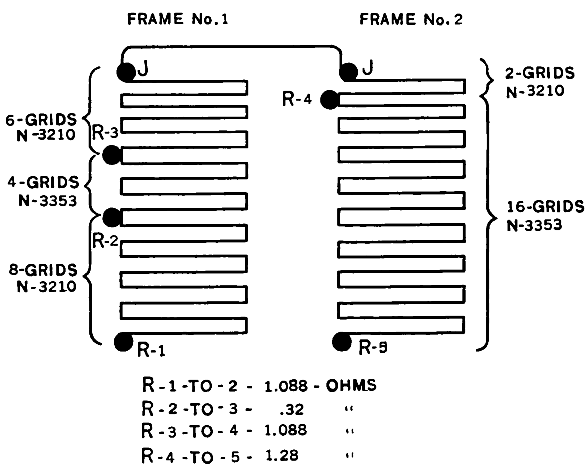
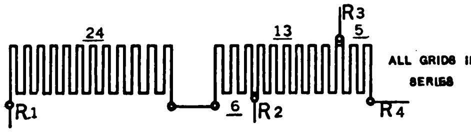


FIG. 92.—Arrangement of grids used with K-28-L controllers and two motors (B. R. T.).



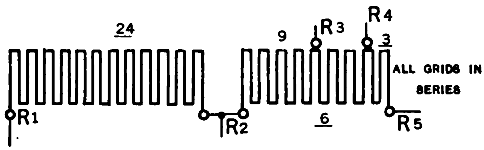
14 – A – 24 + (14 – A6 + 12 – A – 13 + 11 – A – 5) = 48 grids total

R_1 to R_2, 30 grids of 26,514 = 5.32 ohms

R_2 to R_3, 13 grids of 26,512 = 1.47 ohms

R_3 to R_4, 5 grids of 26,511 = 0.45 ohms

FIG. 93.—GE car resistance connections for two GE-800 or 52 motors and K-2 controllers (P. S. Ry.).



12 – A – 24 + (10 – A – 9 + 9 – A – 9) = 42 grids total

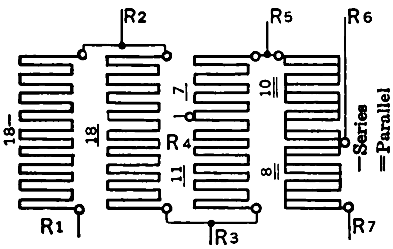
R_1 to R_2, 24 grids of 26,512 = 2.71 ohms

R_2 to R_3, 9 grids of 26,510 = 0.83 ohms

R_3 to R_4, 6 grids of 26,519 = 0.44 ohms

R_4 to R_5, 3 grids of 26,519 = 0.22 ohms

FIG. 94.—GE car resistance connections for four GE-800 or 52 motors and K-11 or K-12 controllers (P. S. Ry.).



10 – A – 18, 7 – A – 18, 6 – A – 18, 8 – B – 18 = 72 grids total

R_1 to R_2, 18 grids of 26,510 = 1.60 ohms

R_2 to R_3, 18 grids of 26,507 = 0.85 ohms

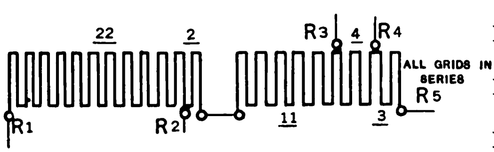
R_3 to R_4, 11 grids of 26,506 = 0.42 ohms

R_4 to R_5, 7 grids of 26,506 = 0.28 ohms

R_5 to R_6, 10 grids of 26,508 = 0.15 ohms

R_6 to R_7, 8 grids of 26,508 = 0.12 ohms

FIG. 95.—GE car resistance connections for four GE 57 (50 h.p.) motors and K-14 controllers (P. S. Ry.).



11 – A – 24 + 9 – A – 18 = 42 grids total

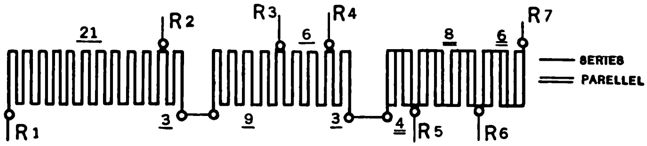
R_1 to R_2, 22 grids of 26,511 = 2.00 ohms

R_2 to R_3, 2 grids of 11 + 11 of 09 = 0.98 ohms

R_3 to R_4, 4 grids of 26,509 = 0.30 ohms

R_4 to R_5, 3 grids of 09 = 0.22 ohms

FIG. 96.—GE car resistance connections for two GE-57 (50 h.p.) motors and K-11 controllers (P. S. Ry.).



11 – A – 24 + 9 – A – 18 + 9B – 18 = 60 grids total

R_1 to R_2, 21 grids of 26,511 = 1.93 ohms

R_2 to R_3, 3 grids of 11 + 9 of 09 = 0.94 ohms

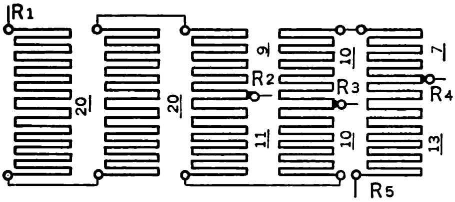
R_3 to R_4, 6 grids of 26,509 = 0.44 ohms

R_4 to R_5, 3 grids of 09 + 4 of 09 = 0.29 ohms

R_5 to R_6, 8 grids of 26,509 = 0.15 ohms

R_6 to R_7, 6 grids of 26,509 = 0.11 ohms

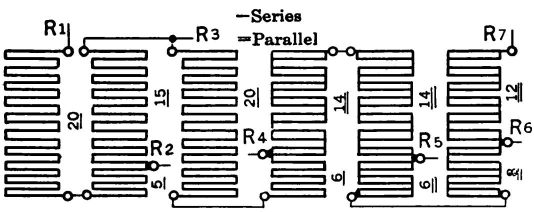
FIG. 97.—GE car resistance connections for four GE-58 or 1000 motors and K-6 controllers (P. S. Ry.).



Total Grids 100—All in series

R_1 to R_2, 49 grids of 7,648 = 2.94 ohms
R_2 to R_3, 21 grids of 3,444 = 0.84 ohms
R_3 to R_4, 17 grids of 2,445 = 0.51 ohms
R_4 to R_5, 13 grids of 9,120 = 0.26 ohms

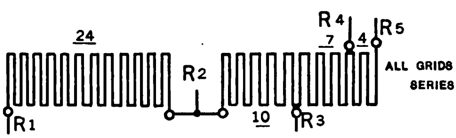
FIG. 98.—Westinghouse car resistance connections for two West. 68 or other 40-h.p. motors and K-11 controllers or other controllers designed for a six-section coil (P. S. Ry.)



Total Grids 120

R_1 to R_2, 25 grids of 7,468 = 1.50 ohms
R_2 to R_3, 15 grids of 2,444 = 0.60 ohms
R_3 to R_4, 26 grids of 9,119 = 0.39 ohms
R_4 to R_5, 28 grids of 2,444 = 0.28 ohms
R_5 to R_6, 14 grids of 2,444 = 0.14 ohms
R_6 to R_7, 12 grids of 2,445 = 0.09 ohms

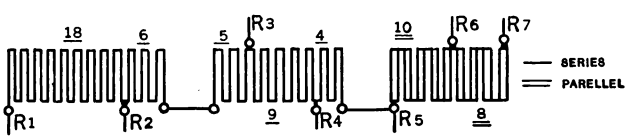
FIG. 99.—Westinghouse car resistance connection for four West. 68 or other 40-h.p. motors and K-6 controllers or other controllers designed for a six-section coil (P. S. Ry.).



13 − A − 24 + 12 − A − 10 + 10 − A − 11 = 45 grids

R_1 to R_2, 24 grids of 26,513 = 3.40 ohms
R_2 to R_3, 10 grids of 26,512 = 1.13 ohms
R_3 to R_4, 7 grids of 26,510 = 0.65 ohms
R_4 to R_5, 4 grids of 26,510 = 0.37 ohms

FIG. 100.—GE car resistance connections for two GE-67 or 80-C motors and K-11 controller (P. S. Ry.).



11 − A − 24 + 8 − A − 18 + 9 − B − 18 = 60 grids

R_1 to R_2,	18 grids of	26,511 = 1.66 ohms
R_2 to R_3,	6 grids of 11 + 5 of	08 = 0.84 ohms
R_3 to R_4,	9 grids of	08 = 0.53 ohms
R_4 to R_5,	4 grids of	08 = 0.24 ohms
R_5 to R_6,	10 grids of	09 = 0.18 ohms
R_6 to R_7,	8 grids of	09 = 0.15 ohms

FIG. 101.—GE car resistance connections for four GE-67 or 80 C motors and K-6 controller (P. S. Ry.).

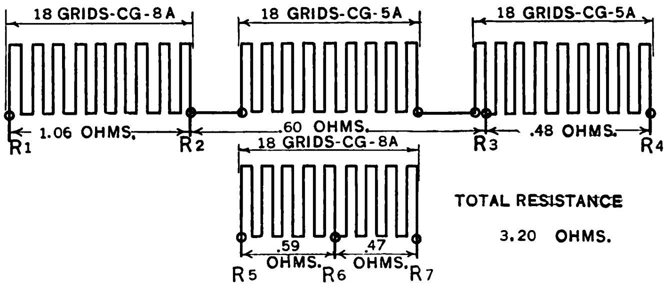
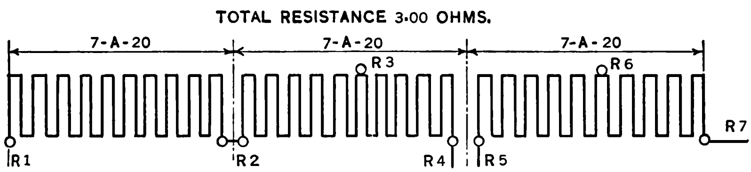


Fig. 102.—Construction and connection of GE car resistance for four GE-57 motors and K-35 controller (P. S. Ry.).



R_1 to R_2, 20 grids of 26,507 = 1.00 ohms
R_2 to R_3, 11 grids of 26,507 = 0.55 ohms
R_3 to R_4, 9 grids of 26,507 = 0.45 ohms
R_5 to R_6, 11 grids of 26,507 = 0.55 ohms
R_6 to R_7, 9 grids of 26,507 = 0.45 ohms

Fig. 103.—Construction and connection of standard car resistance for four GE-57 motors and K-35 controller (P. S. Ry.).

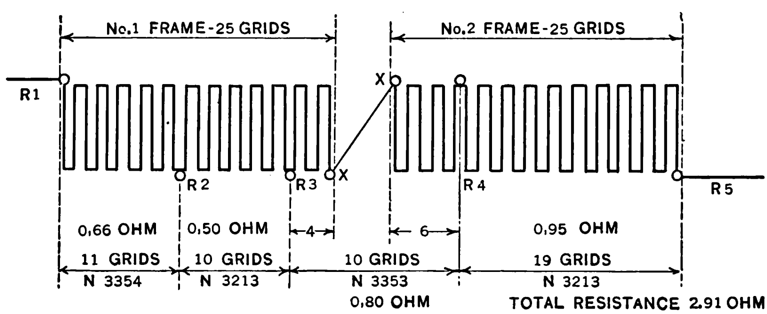


Fig. 104.—Construction and connection of Westinghouse car resistance, style No. 55149, for West. 101-B-2 motors and K-28-B controller (P. S. Ry.).

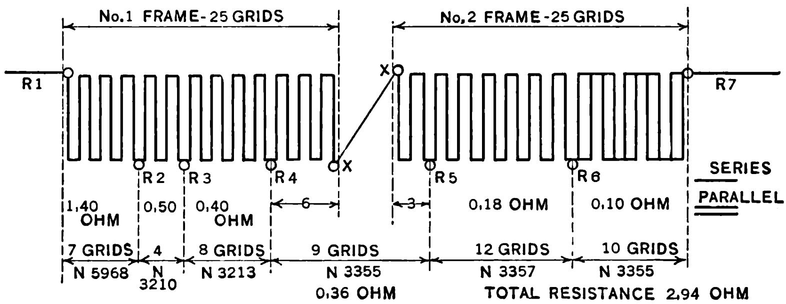


FIG. 105.—Construction and connection of Westinghouse car resistance, style No. 55147, for four West. 101-C motors and K-6 controller (P. S. Ry.)

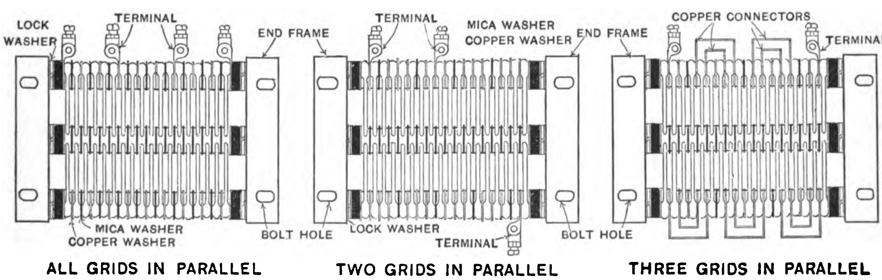


FIG. 106.—Method of making connection between Westinghouse grids.

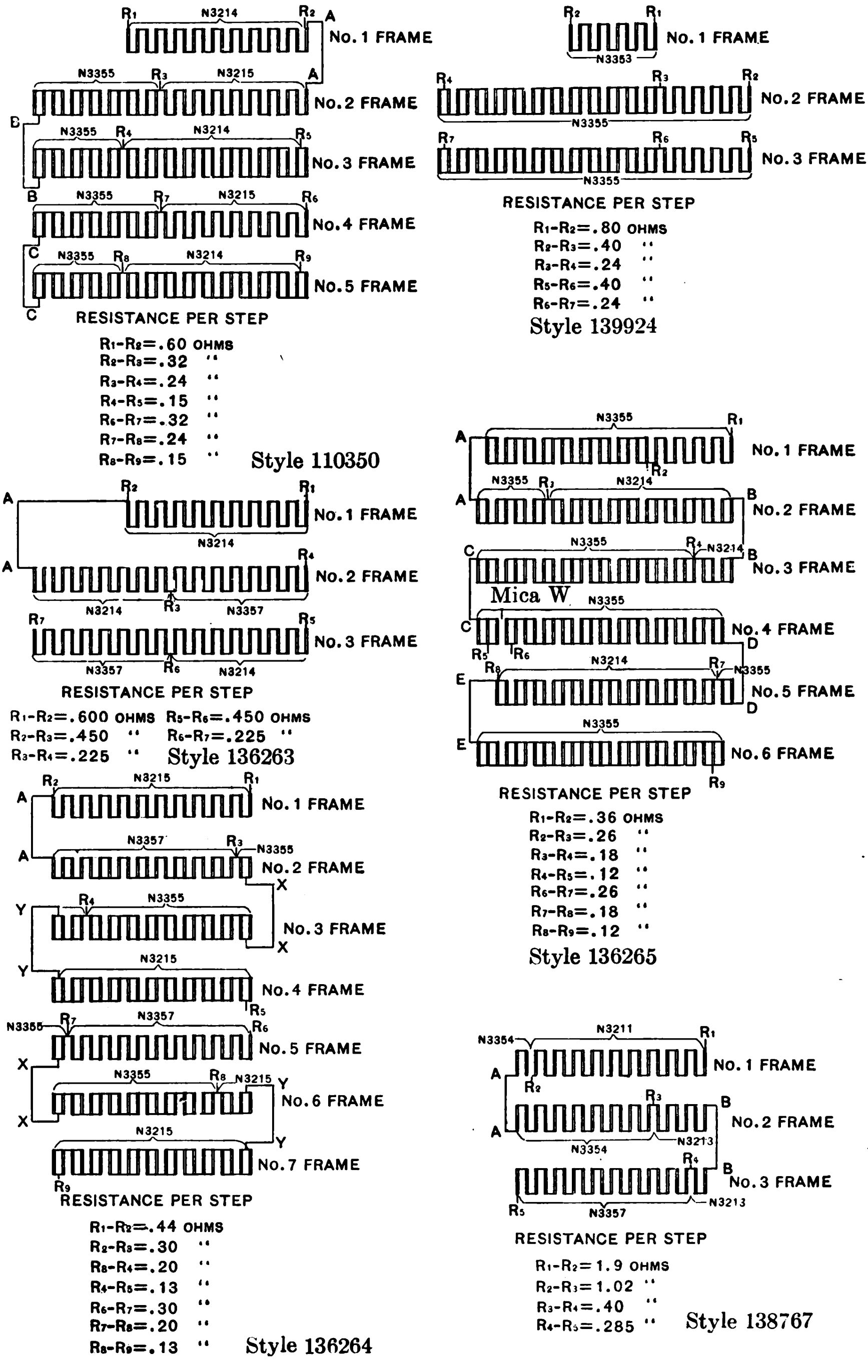


FIG. 107.—Combinations and steps of Westinghouse grids.

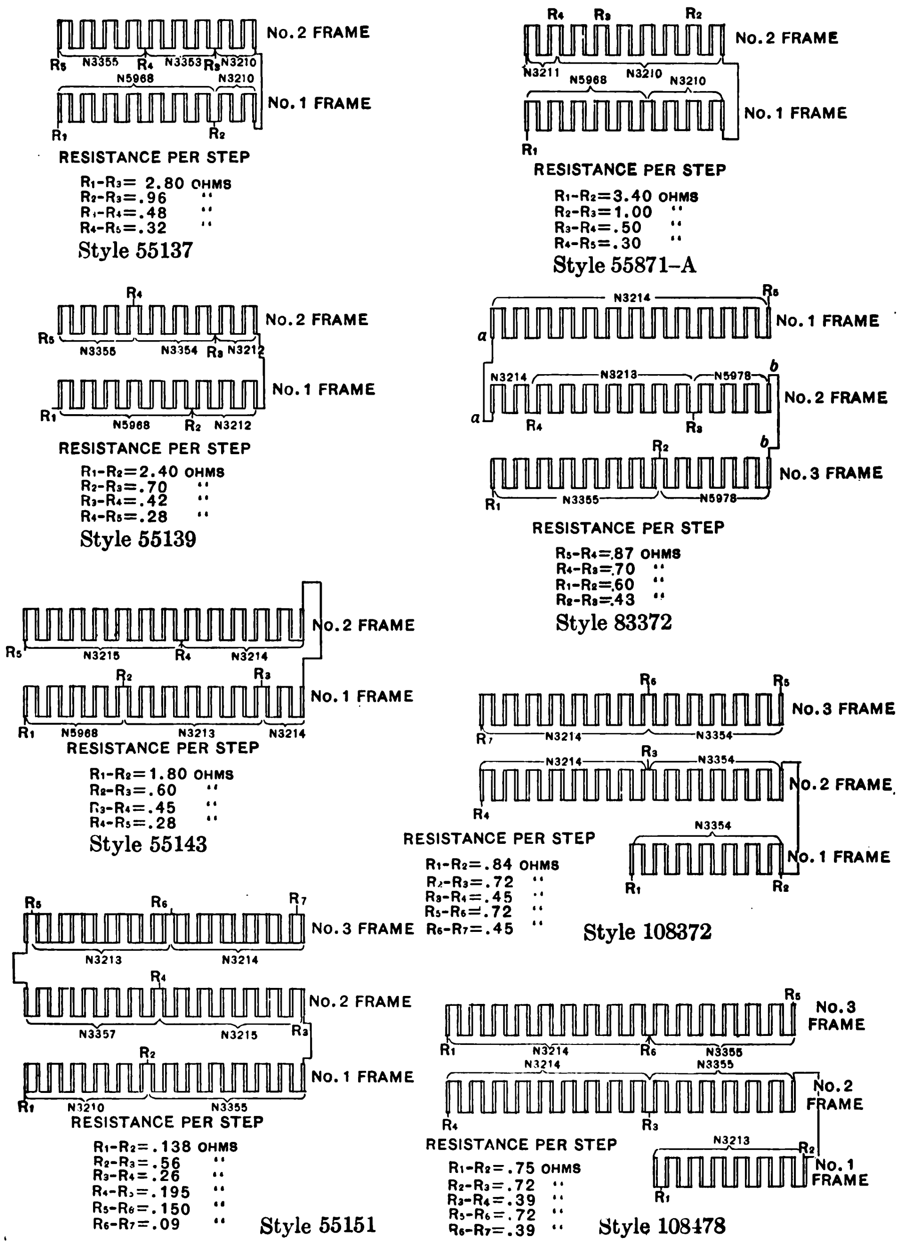
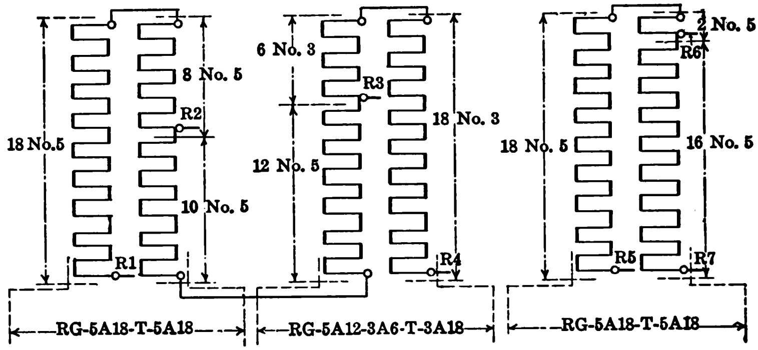


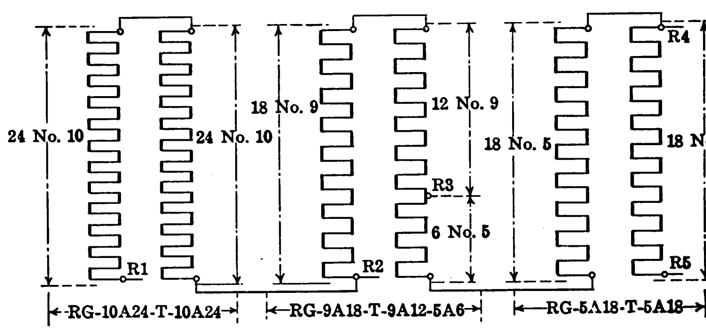
FIG. 108.—Combinations and steps of Westinghouse grids.



Resistance per Division

R1-R2 = .57 Ohms.
R2-R3 = .48 "
R3-R4 = .36 "
R5-R6 = .44 "
R6-R7 = .35 "
Total = 2.20 "

Fig. 109.—Connections of RG. rheostats to be used with K-35 G2 controller



Resistance per Division

R1-R2 = 2.40 Ohms.
R2-R3 = 1.50 "
R3-R4 = .528 "
R4-R5 = .396 "

Resistance by Step

1 = 4.824 Ohms.
2 = 2.424 "
3 = .924 "
4 = .000 "
5 = 2.424 "
6 = .924 "
7 = .396 "
8 = .000 "

Fig. 110.—Connections of RG rheostats used with K-36-J controllers and four GE-210 motors connected two in series as one motor.

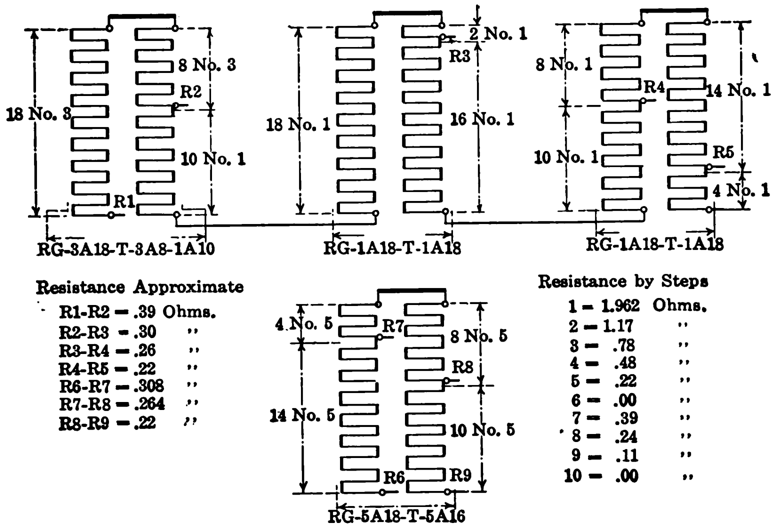
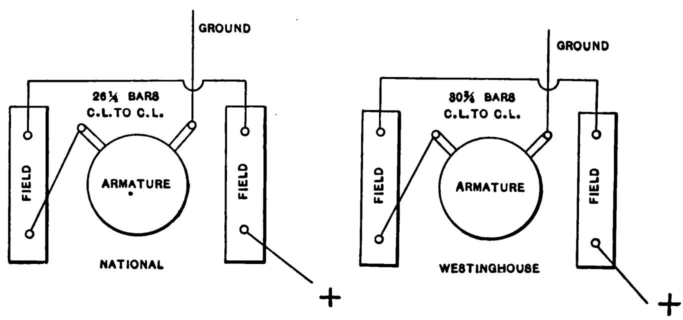


FIG. 111.—Connections of RG rheostat for four 50 h. p. motors and K-34-D controller.



FIGS. 112 AND 113.—Connections for National and Westinghouse compressors (Baltimore).

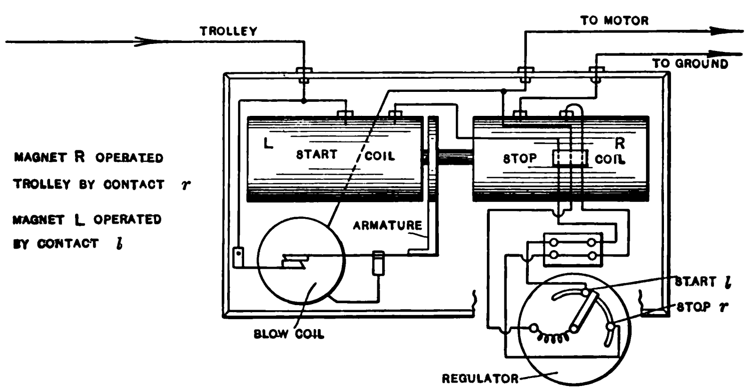


FIG. 114.—Connection of Christensen air governor (P. S. Ry.).

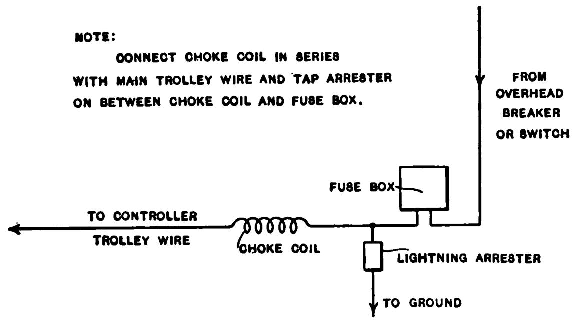
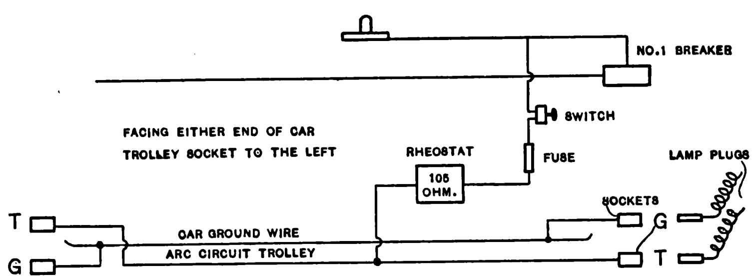
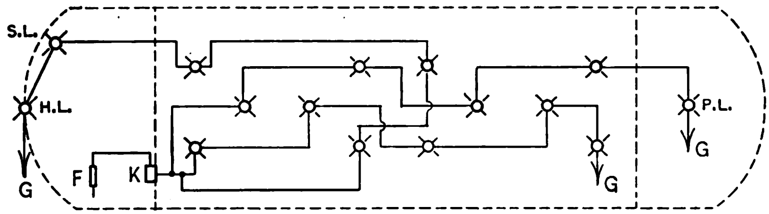


Fig. 115.—Connections of choke coil and lightning arrester (P. S. Ry.).



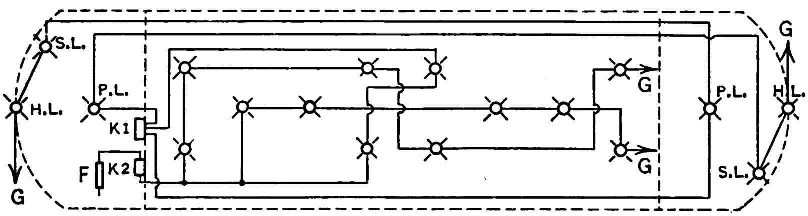
TROLLEY AND GROUND CROSSED ON No. 2 END

Fig. 116.—Arc light connections for double-end car (P. S. Ry.).



H.L. = HEADLIGHT
S.L. = SIGN LIGHT
P.L. = PLATFORM LIGHT
K = LIGHT SWITH
F = FUSE UNLESS IN SWITCH

FIG. 117.—Light connections for single-end car (P. S. Ry.).



H.L. = HEADLIGHT
S.L. = SIGN LIGHT
P.L. = PLATFORM LIGHT
K 1 = 3 WAY SWITCH
K 2 = MAIN SWITCH
F = FUSE UNLESS IN SWITCH

FIG. 118.—Incandescent lamp circuits for double-end car (P. S. Ry.).

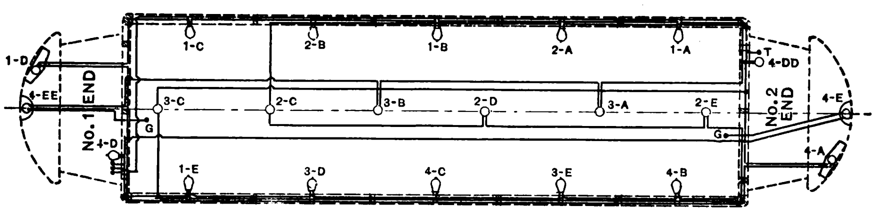


FIG. 119.—Lighting layout for a car with 28-ft. body (B. R. T.).

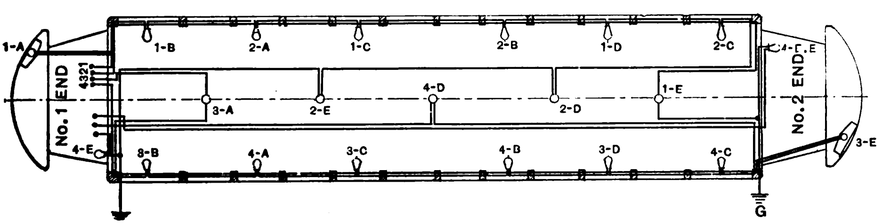


FIG. 120.—Lighting layout for a convertible car 42 ft. 6 in. overall (B. R. T.).

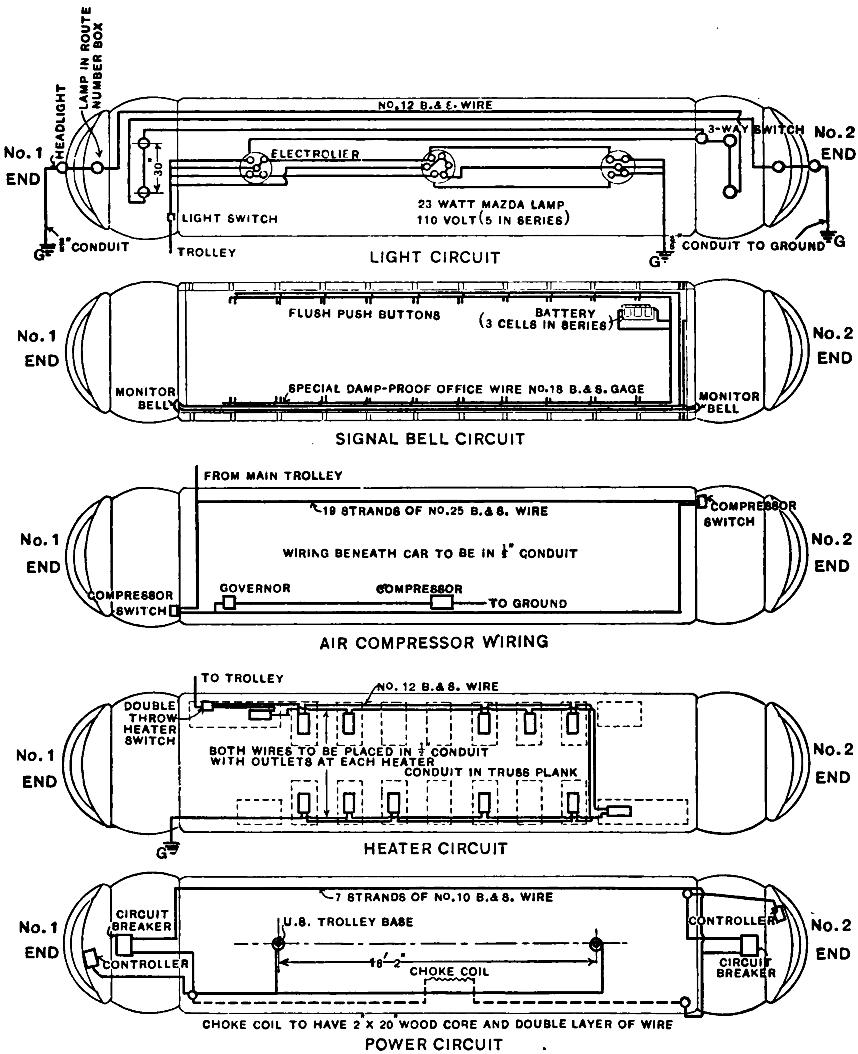
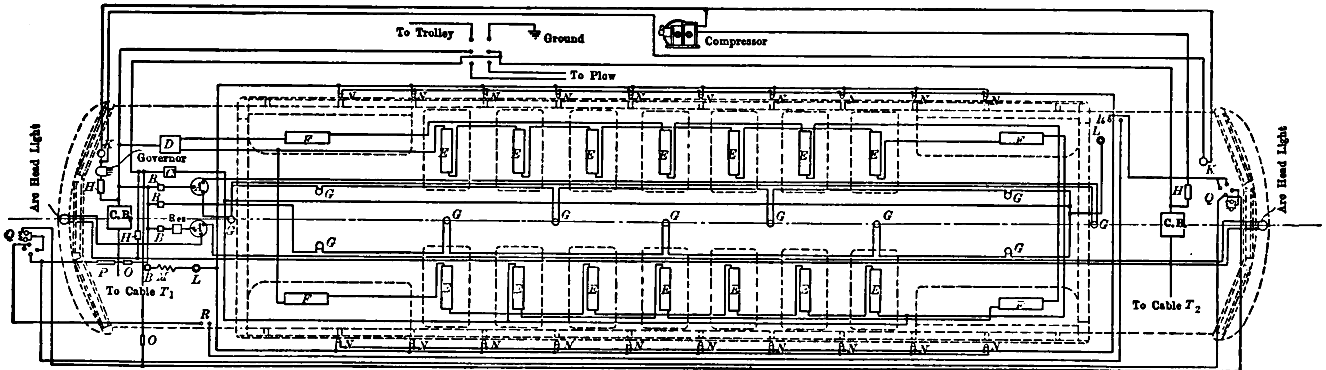


FIG. 121.—Wiring diagrams of 1913 type cars, United Railways & Electric Company of Baltimore.



Key

A	3 Point Snap Switch	*G*	Socket, Shade Holder & Holophane Reflector	*O*	1 Amp. Inclosed Fuse
B	Combination Switch & Cut-out	*H*	10 Amp. (Inclosed Fuse)	*P*	5200 Ohm Resistance
C	15 Amp. Cut-out (Inclosed Fuse)	*K*	500 Volt 10 Amp. Snap Switch	*Q*	Light box & 2 Way Switch
D	Switch & Cut-out	*L*	Buzzer	*R*	Door Switch.
E	Heater, 375 Watts	*M*	Resistance Unit		
F	Heater, 375 Watts	*N*	Push Button		

FIG. 122.—Tungsten lighting, heating, door and buzzer circuits of pay-within cars for the Capital Traction Company, Washington, D. C.

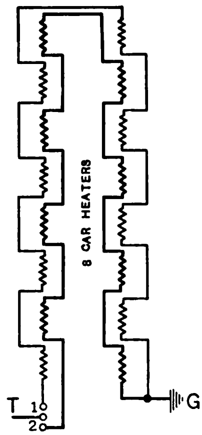


FIG. 123.—Wiring of Consolidated 93 heater (B. R. T.)

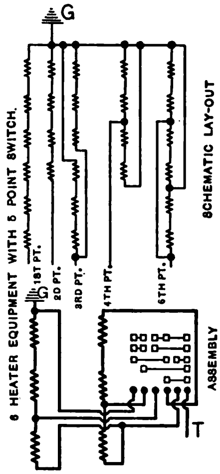


FIG. 124.—Wiring of Consolidated 103 T heater (B. R. T.).

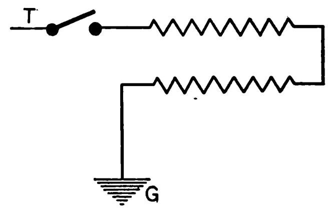


FIG. 125.—Wiring for Consolidated No. 118 W special heater (B. R. T.).

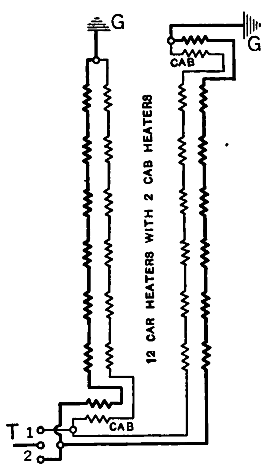


FIG. 126.—Wiring for Consolidated No. 143 LL heater.

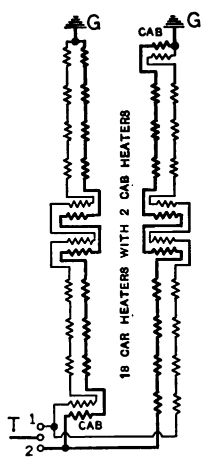


FIG. 127.—Wiring for Consolidated 146X (B. R. T.).

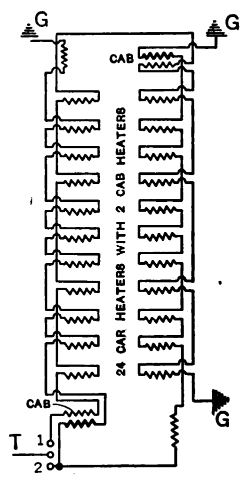


FIG. 128.—Wiring for Consolidated No.192 heater (B. R. T.).

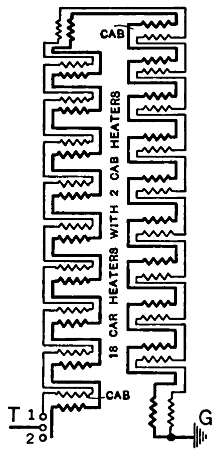


FIG. 129.—Wiring for Gold two-coil column heater (B. R. T.).

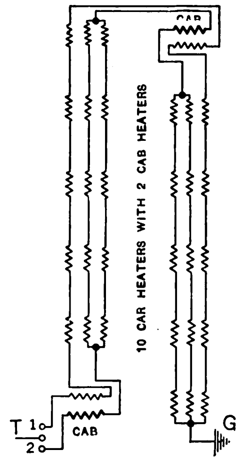


FIG. 130.—Wiring for Gold three-coil panel heater (B. R. T.).

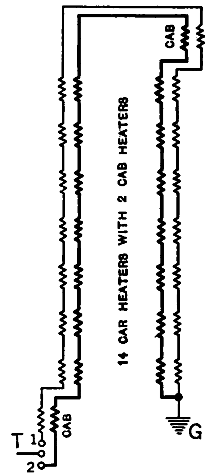


FIG. 131.—Wiring for Gold two-column panel heater (B. R. T.).

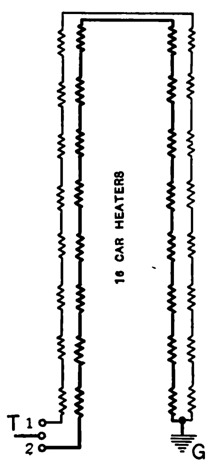


FIG. 132.—Wiring for Gold two-coil panel heater (B. R. T.).

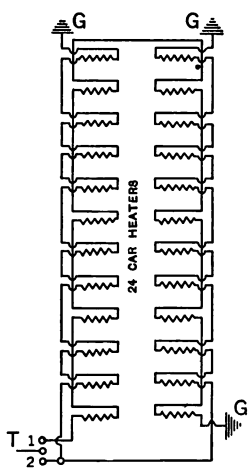


FIG. 133.—Wiring for Consolidated No. 192 heater (B. R. T.).

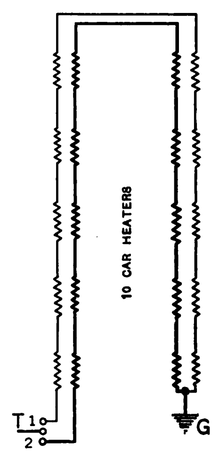


FIG. 134.—Wiring for Consolidated No. 167 heater (B. R. T.).

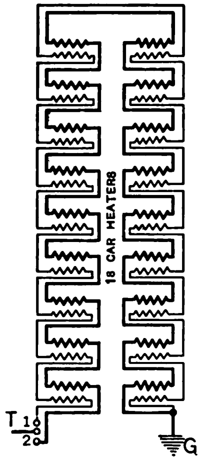


FIG. 135.—Wiring for Consolidated Nos. 217 RJ, 192 W and Gold two-coil column heaters (B. R. T.).

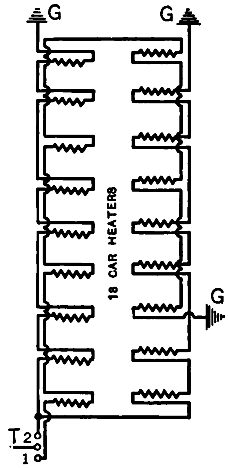


FIG. 136.—Wiring for Consolidated No. 192 heater (B. R. T.).

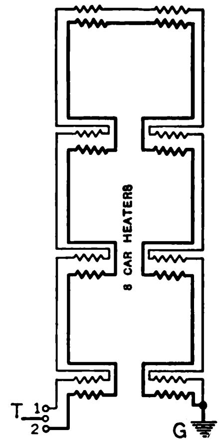


FIG. 137.—Wiring for Consolidated No. 118 WE heater (B. R. T.).

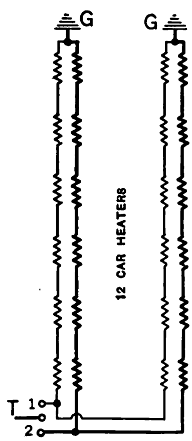


FIG. 138.—Wiring for Consolidated No. 143 LL heater (B. R. T.).

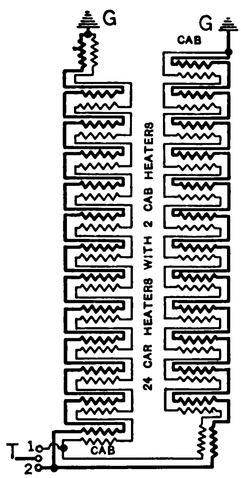


FIG. 139.—Wiring for Consolidated 217 R heater (B. R. T.).

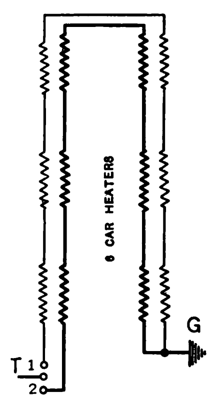


FIG. 140.—Wiring for Consolidated No. 143 LL or L. S. heaters (B. R. T.).

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