CHAPTER IX

ROLLING-STOCK AND EQUIPMENTS

Tramway-car Bodies.—Very radical departures in design from horse-car practice had to be made to render these cars suitable for electric traction. The underframing more particularly had to be strengthened to meet the severe conditions of a self-propelled vehicle, with higher speeds and more rapid acceleration. Accommodation also had to be provided for the car-truck to which the motors are attached.

The double-deck car recommends itself as affording seating accommodation both under cover and in the open, and having with a given over-all dimension the greatest seating capacity obtainable.

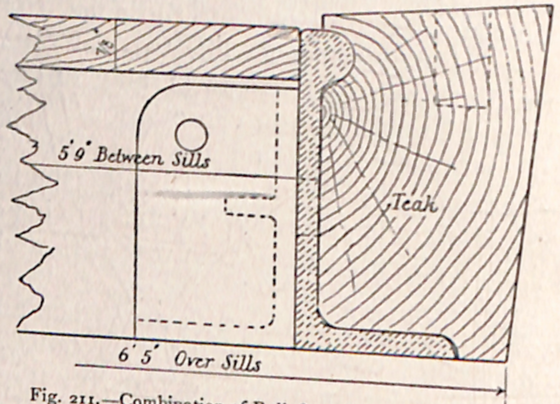

Fig. 211.—Combination of Bulb Steel Section and Teak for Car Side-sills

Figs. 208–10 show the exterior and interior of a standard, top-covered, double-decked car, as used in the Glasgow Corporation Tramway System. It is to be noted that the ends have a vestibule which protects the motor-man and the conductor from the effects of the weather.

The main underframing of the cars should be preferably of teak or oak. In the case of long bogie cars it is generally advisable to reinforce the timber of the side-sills with steel section, and for this purpose bulb section, as shown in fig. 211, is preferable to a channel section, as it allows the mortising of the side-sills for the corner and side pillars to be carried out in the usual manner. All mortised joints should first be covered with white lead, and brought together at a driving fit.

The selection and seasoning of the timber is a most important operation, upon which depends to a great extent the life of the car.

Selection of Timber.—The various kinds of timber suitable for car construction are offered to builders in the general market in two forms, namely, in the log and in the plank, and different builders make their selection from either or both as circumstances require.

Selection from log stock to be cut into planks for car work requires the greatest skill, and none but those who have had large experience in this particular direction succeed in securing satisfactory results. The main advantages of selection from this form are: the long lengths, wide widths, and minimum first cost that can be secured. Its disadvantages are: the large amount of waste when converting such logs into planks, and the long time required for seasoning before it can be used in car work.

Selection from plank stock direct offers a much safer and more satisfactory method in the long run. Its advantages are: an open inspection

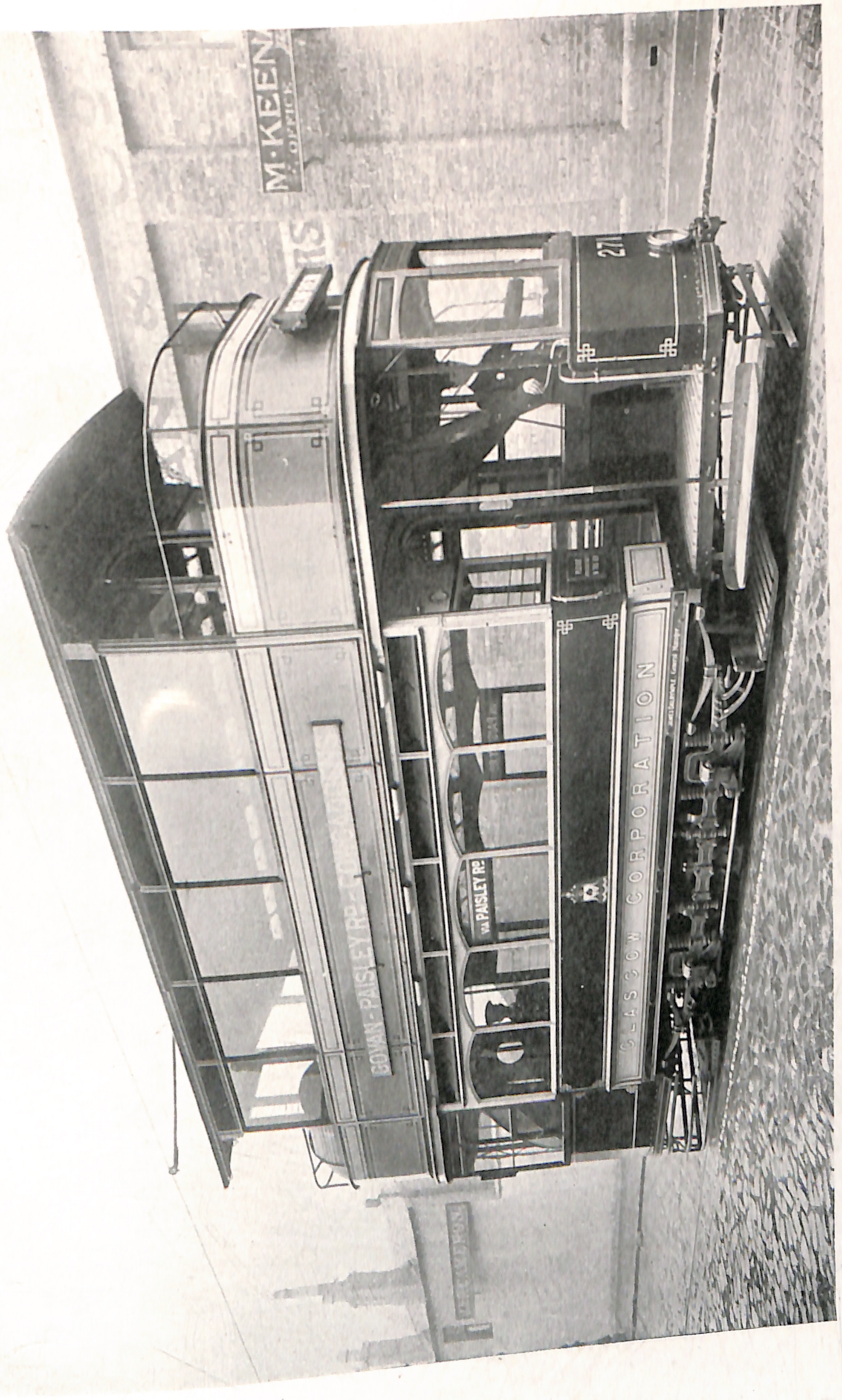

Fig. 208.—Exterior of Glasgow Corporation Standard Double-deck Car

of each plank; a minimum amount of waste in cutting to the various sizes required in the work, and an advanced stage of seasoning. Its disadvantages are: the difficulty of securing long lengths and wide widths; but, as advanced orders can be placed to cover these disadvantages, selection from plank stock is considered the most satisfactory.

The kinds of timber most used in car construction are as follows:—

Main Framing.	Outside Finishing.	Inside Finishing.
Teak Oak Pitch Pine Ash	Teak Mahogany Canary Whitewood	Teak Mahogany Quartered Oak Ash

After the timber has passed through the mill, where it is cut to the desired shape, it is placed in the hands of the body-makers, and on completion of the framing, panelling, roofing, and fixing of the platforms it is taken possession of by the painters and inside finishers, who are responsible for the general appearance of the car as the public see it.

The car body has to be securely trussed to prevent it getting hog-backed and the platforms sinking. The trusses should be arranged so that they may from time to time be pulled up, to counteract any tendency to sagging, and when pulling up the trusses the platforms should be jacked up to assist the pull.

The process of painting takes considerable time, as may be deduced from the following short description of the operation:—

Painting and Varnishing.—This is one of the most important steps in the production of a completely finished car, for on it not only depends the general appearance of the work as a whole, but the durability of all perishable parts as well.

The various steps involved in the work of this department may be stated as follows: Priming, filling, rubbing down, second priming, colouring, second rubbing down, decorating, and varnishing, all in the order named. These various steps, with the number of coats in each, may be stated in the following scheme, which approximates as nearly as may be to the average standard practice:—

Priming.—

First coat lead.

Stopping all nail-holes and various other imperfections.

Second coat lead.

Second stopping of nail-holes and imperfections.

Filling.—

Four coats filling (sometimes called rough stuff).

One coat stain (sometimes called the guide coat).

Rubbing Down.—This step consists of going over the car with a large block of pumice-stone and water, and with long sweeping strokes rubbing through the guide coat mentioned above. When the guide coat is entirely removed in this manner, if the work has been carefully done, the result will be a hard smooth surface, furnishing a good foundation for the succeeding step, viz. second priming.

Two coats of lead constitute this step, which, together with further stopping, if found necessary, prepares the car for colouring.

Colouring.—From two to four coats of colour are required, according to circumstances. If the colour used is light or semi-transparent, four coats are necessary to produce a "solid" appearance. In all cases the last coat should have a proportion of hard-drying varnish, which, when rubbed down with powdered pumice-stone and water, gives a hard bright surface on which to decorate, line, letter, and number.

Varnishing.—This step consists of two coats of hard-drying body varnish, the last coat being rubbed with powdered pumice-stone and water. One coat of fine body-finishing varnish completes the work. It is essential that in the last stages of the work as even a temperature as possible should be observed, 60° F. being considered essential to secure the best results.

General Remarks.—When constructing the car underframing, allowance must be made for the provision of trap-doors opening up over the motors; this is necessary in order to facilitate inspection and attention. These traps should be provided with countersunk handles for lifting by. The floor of the cars and the top deck, if of that type, should be provided with wearing strips; these serve the dual purpose of saving wear to the floor proper and of keeping the passengers' feet dry. In putting in these strips, they should be laid in such a manner as to interfere as little as possible with the natural drainage and the sweeping out of the car. The platforms should also be covered in the same manner.

The ends of the platforms should be provided with steel dash-plates, on which may be mounted the headlight fittings; these plates are supported on wrought-iron posts. Projecting beyond the dash-plates should be fixed the buffer irons, attached to the end of the platform bearers. These are either of channel-, angle-, or T-section steel, and may be pressed to shape between dies with a special machine in one heat.

The windows of the cars should be glazed with a plate glass, usually about $\frac{1}{4}$ inch thick, set in with rubber.

The doors at the end of the car body may be of the single or twin type. The latter, though convenient, are hardly so reliable in action as the single type. The doors are slung on sheaves running on a track provided for them, and should be kept in position with guides.

The roof of a double-deck car, of course, has to be very much stronger than that of the single-decker. Provision has to be made not only for the weight of passengers to be carried, but for the strain consequent upon the use of a trolley standard some 5 feet 6 inches or 6 feet high. The ceilings employed may be either tongued and grooved in alternate coloured woods, or of a more elaborate class, bird's-eye maple veneer, or decorated mill-board. The latter is very popular, and is less likely to give trouble and is easier to clean than the veneer, and when dirty it may be redecorated in any style required. Above the ceiling is a light roof of, say, $\frac{1}{2}$-inch

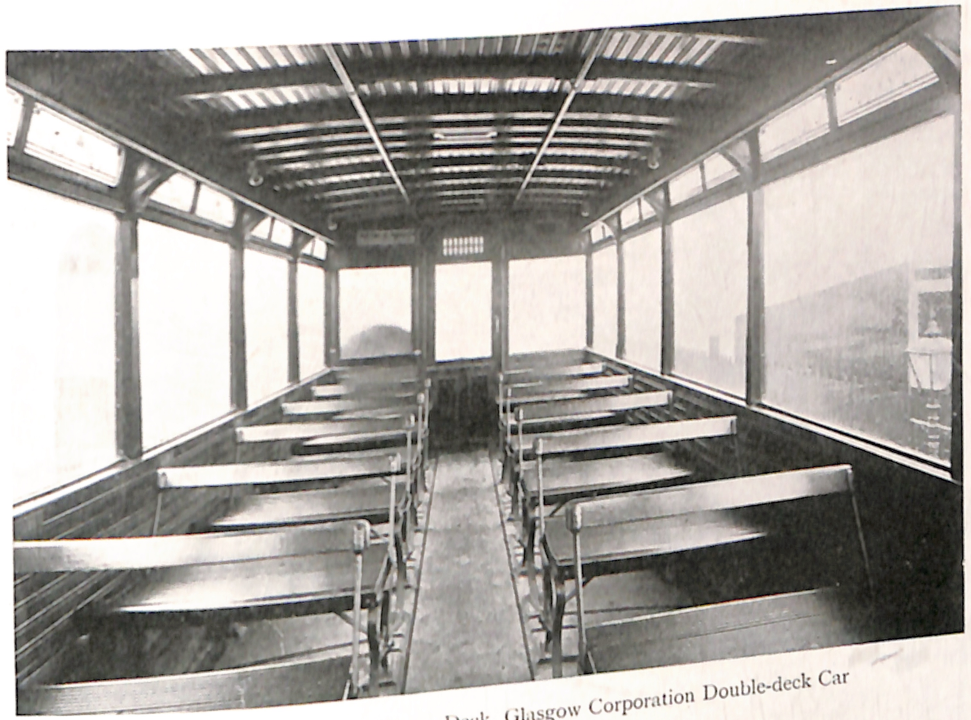

Fig. 209.—Interior of Upper Deck, Glasgow Corporation Double-deck Car

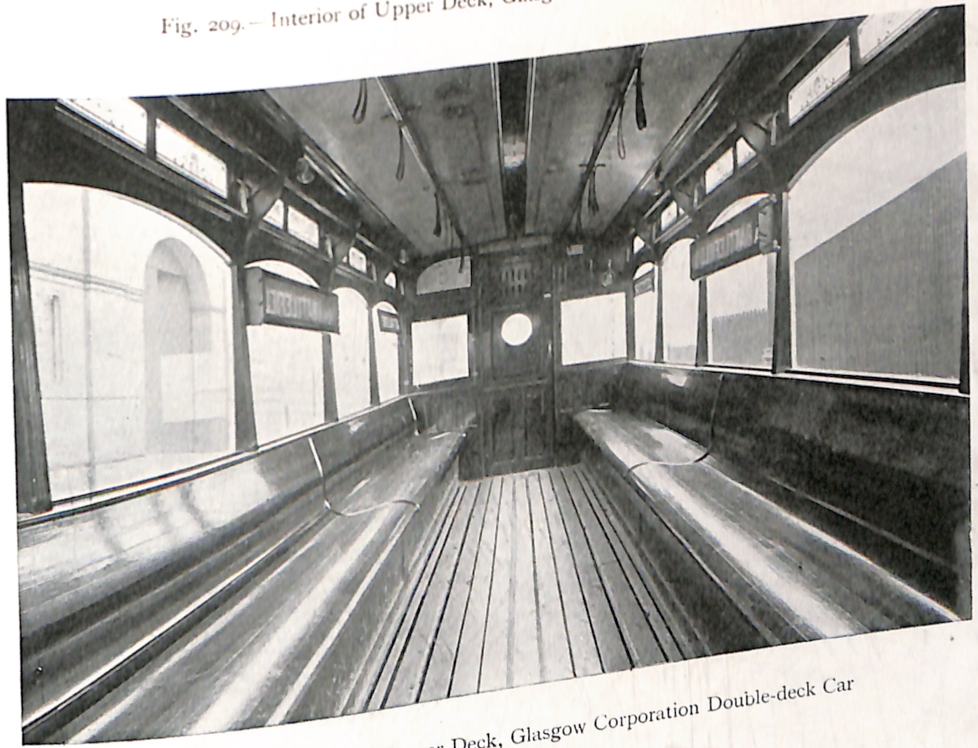

Fig. 210.—Interior of Lower Deck, Glasgow Corporation Double-deck Car

material, tongued and grooved, nailed to the hoop-sticks. On this is placed a layer of cotton duck, applied wet in a coat of white-lead paint. This prevents the percolation of any water through the roof. The upper-deck boards are then put on, these too being tongued and grooved. The usual thickness of these boards is $\frac{7}{8}$ inch.

The general practice for the top-deck seats is to employ the ordinary reversible garden type screwed down to the deck. The seating is of lath and space, and they do not readily hold the rain. There are, however, a number of "dry seats" employed too numerous to mention. For the inside seats, which are generally of the longitudinal type, a variety of forms may be adopted, the most prominent being the lath and space of alternate coloured woods; these are sometimes covered with removable carpet. Also we have the perforated veneer, the upholstered or cushioned seat, the upholstered or woven-cane spring-back seat, &c.

The appearance of a modern car is greatly augmented by the use of embossed mouldings, carving, and other decorative devices, and we illustrate in fig. 212 the interior of a Liverpool standard car, as constructed by the Electric Railway and Tramway Carriage Works of Preston. This illustration shows the improved roof construction introduced by these makers into car body design, the chief advantages gained being the greater air capacity of the car interior and the better facilities for ventilation. This design has now been adopted as a standard by nearly all British car builders.

Motors.—The design of a modern series-wound tramway motor is a much more difficult problem than is generally realized, owing to the very small space that is available under a car, the limited room on the car axle (even with a 4-feet-8½-inch gauge), and the heavy duty expected of the motor, combined with the exposed position in which it is placed. It is not surprising, therefore, since the introduction of electric traction, motor design has undergone many important changes, each advance being made after actual experience had proved the then existing methods both faulty and unreliable. Each change has been in the direction of rendering the motor impervious to water, dust, vibration, and load variation.

In order to get the required output from the motor, and to keep its dimensions within possible limits, a considerable gear reduction has to be obtained. It has been universally accepted that the spur-gear keyed and clamped on to the car axle itself, and meshing directly with a pinion-wheel directly attached to the armature shaft, offers the best solution to the problem. Fig. 213 illustrates the modern gear-wheel both before the teeth are cut and after. The same illustration shows the gear-case or housing, which enables the gear and pinion wheels to be run partially immersed in grease. The most suitable material for the gear-case is malleable cast iron. The gear-wheel should be manufactured from a high grade of cast steel with a view to strength and long life. It should be cast in halves, and after the faces of the halves are accurately machined, and the hub bored to the proper size for the car axle, the halves should be brought together, and the teeth cut by special machines from the solid metal. A keyway is cut in the bore for the axle key.

The pinion-wheel should be of softer material, usually being of forged steel, the teeth being cut from the solid as in the case of the gear-wheel.

We illustrate in fig. 214 a No. 25A motor, built by Dick, Kerr, & Co., Limited, of Preston, Lancashire.

The motor frame consists of two bowl-shaped steel castings, on to which are cast bearing-boxes for the armature and car axles. As this motor casing fulfils the part of magnet yoke, as well as being the mechanical frame of the machine, the steel should be of low magnetic reluctance.

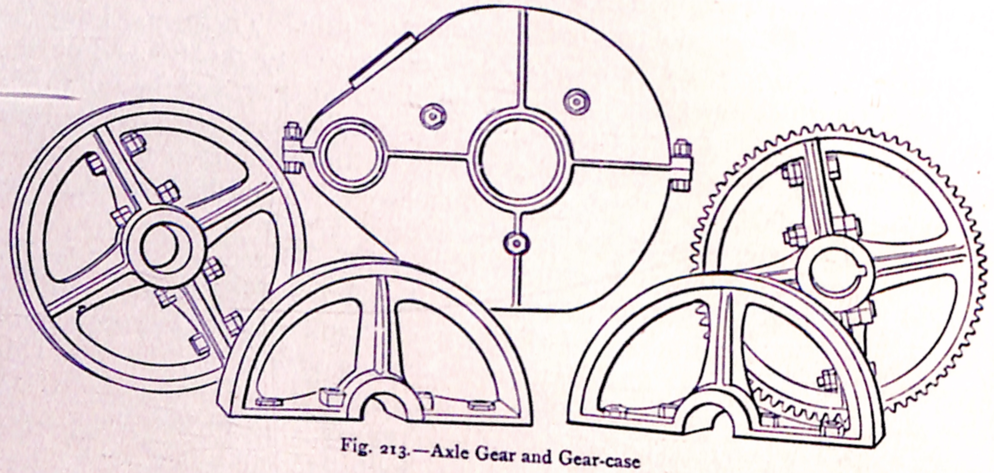

Fig. 213.—Axle Gear and Gear-case

To the frame are bolted the pole-pieces, arranged two in each half of the motor case, which is divided horizontally in line with the centre of the armature shaft. These pole-pieces are built up of laminated steel punchings, a precaution necessary to prevent heavy eddy currents and consequent loss in efficiency. The pole-pieces are so constructed that they hold in position the field coils surrounding them. It is particularly important that the coils be held sufficiently firmly to prevent the vibration of the motor chafing the insulation. The coils are generally protected from the edge of the pole-pieces by a gun-metal frame.

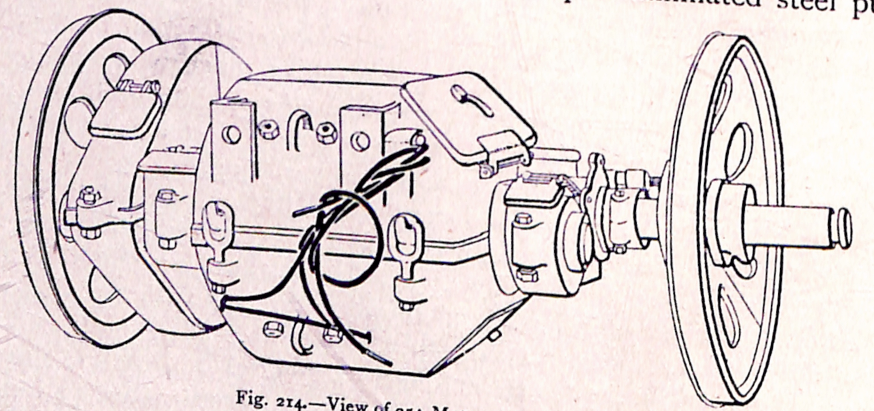

Fig. 214.—View of 25A Motor mounted on Axle

The field coils should be heavily insulated with water-resisting material,

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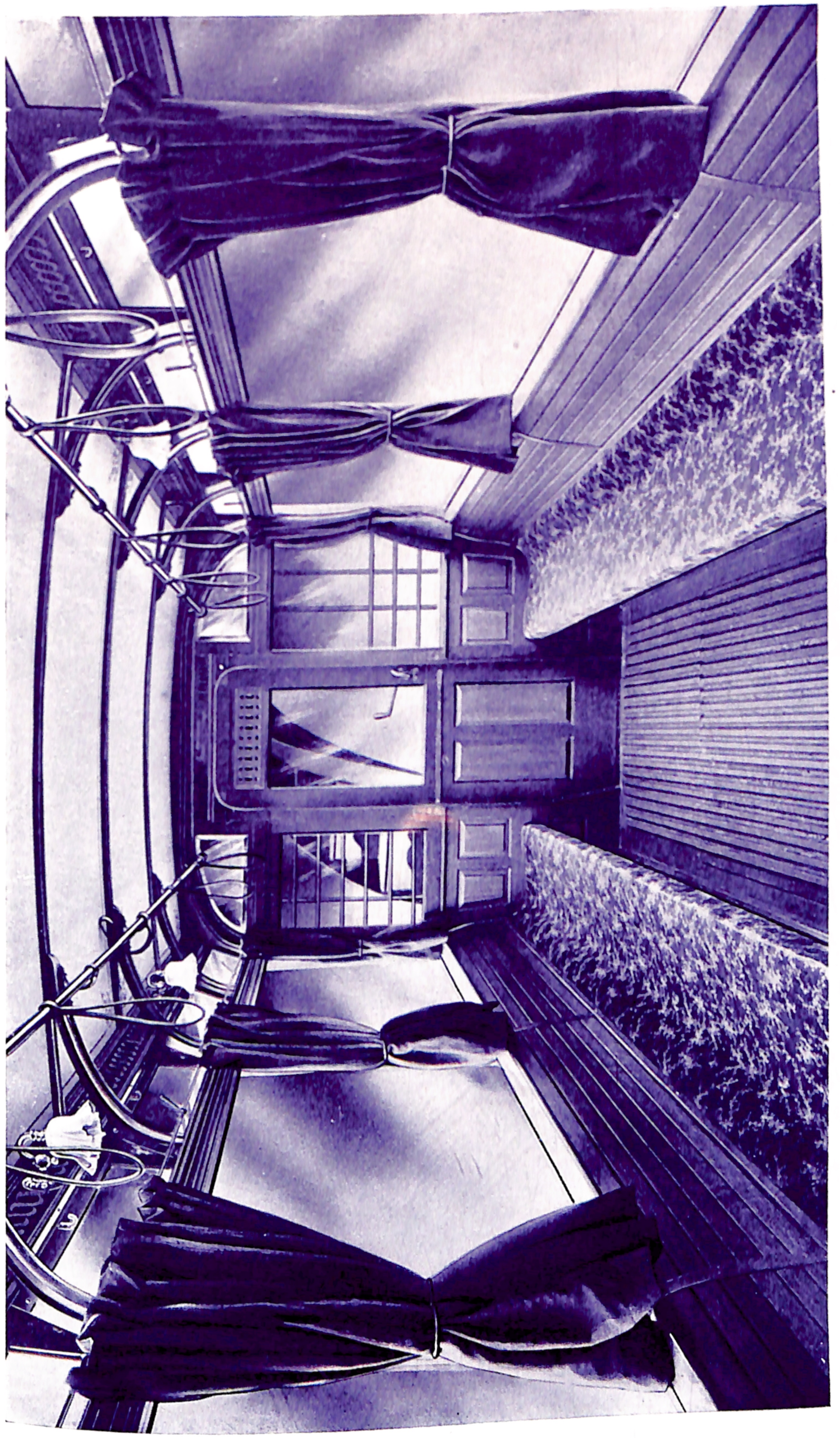

Fig. 212.—Interior of Liverpool Standard Car

and with a view also of withstanding the vibration to which they are bound to be subjected.

The armatures are almost universally of the slotted-core type, the core being built up of thin sheet-steel punchings, each separated from the other by a thin layer of japan, or other insulating medium, in order to prevent excessive core losses. The punchings are carefully annealed, and every endeavour is made to give the armature core a high magnetic conductivity and low hysteresis. The punchings provide a hole in the centre for the armature shaft, and for the key which is fitted into the shaft. The punchings are also provided with holes stamped in them; these have a symmetrical relationship to the keyway, so that when arranged on the shaft they all come opposite one another. This provides the core with the necessary ventilation, which, together with the special spacing discs, placed at intervals, allows a sufficiently free passage for the air to ensure proper cooling.

The commutator is built up on a hub, which is fitted and keyed to the armature spindle. The copper employed is usually hard-drawn or drop-forged, each bar being insulated from its neighbour by pure mica strip, and from the frame by a mica compound moulded to suitable shape. The number of bars employed depends, of course, entirely on the design of the motor, varying considerably with different makers, sizes, and speeds. Tramway motors are presumed to be worked with a pressure of 500 volts, but the motors to be of any practical service must operate equally satisfactorily with a 10-per-cent variation from the normal voltage. Also, a tramway motor must run sparklessly in either direction from no load to 50 per cent overload without the position of the brushes being changed. In the best tramway motors of to-day these conditions are fully met with absolute success. The commutator bars should have sufficient depth to allow the wear and periodical turning up necessary, and an allowance of 2 inches reduction in diameter at least should be provided for this purpose.

The brushes should be held on to the commutator by springs, giving a sufficient pressure to ensure the brushes not jumping from the face of the commutator over bad rail-joints, crossings, &c. The springs should be arranged to take up the wear of the brushes automatically.

The armature coils should all be wound on proper formers, thus ensuring that each one is interchangeable with the other. The coils are wound with cotton-covered wire, which, after it is wound on the former, is dried in an oven. After this it is dipped and dried alternately in special insulating varnish till sufficiently impregnated. The varnish should when dry be elastic, and have no tendency to crack when the coil is being placed on the armature core. The coils, before being forced into the slots of the armature core, are further insulated and protected by mica, press-board, and linen, then taped, and again dipped in varnish and dried. After all the coils are in position the connections are carefully soldered into the slits in the commutator bars provided for that purpose. In the illustration fig. 215 we show all the parts of a motor before assembly, and in the next illustration, fig. 216, we show the same motor assembled, but with the lower half let down for inspection. It is very important that the motors be arranged so as to be capable of being opened up while mounted on the car axle, with the armatures either suspended to the top half or resting in the lower half, as may be found most convenient for the particular form of inspection required.

The rating of tramway motors is, of course, quite different from that of generators and stationary motors, the conditions of their operation in service requiring that they shall only develop their full-load horse-power for short periods at a time. A standard rating has, by common consent, been accepted by American manufacturers, and this rating has been generally accepted in this country as well, the specification of which runs as follows: "After one hour's continuous run at the full rated load the temperature of any part of the motor windings, taken either externally or

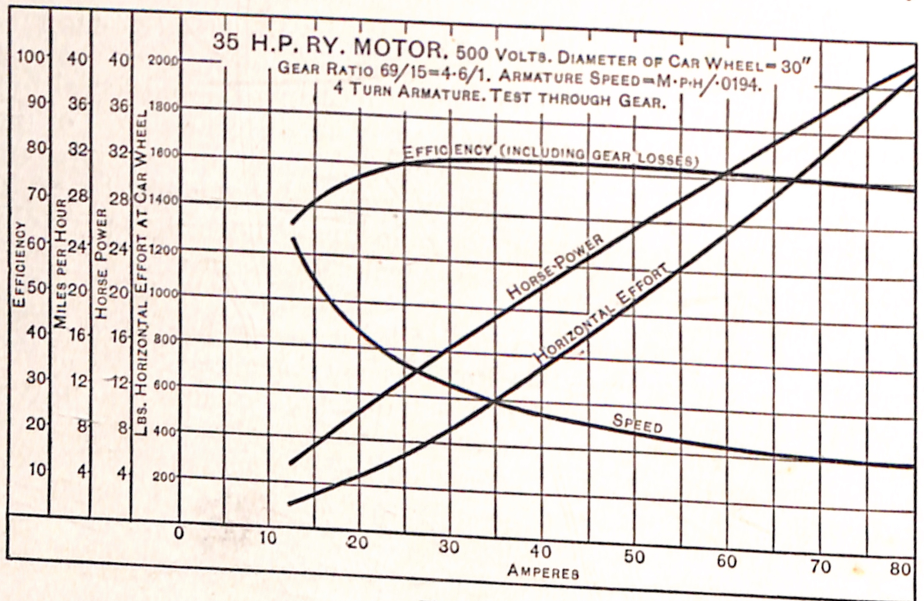

Fig. 217

internally, shall not exceed a rise of 75° C. above the temperature of the surrounding atmosphere taken at a distance of not more than 2 feet from the motor, subject to the temperature of the atmosphere being not more than 25° C. The tests to be made with the commutator cover open in order to approximate to the actual conditions of service as regards heat dissipation." It is convenient to show the efficiency, tractive effort, speed, and horse-power obtained by the various ampere inputs by means of curve sheets, one of which is reproduced in fig. 217, representing a 35-horse-power motor built by Dick, Kerr, & Co., Ltd., of Preston, Lancashire. We further reproduce the curves of the Westinghouse No. 49 motor (fig. 218).

The curves are obtained by actual observation of the performance of the motor, and are plotted to scale at the various ampere readings taken. It is, of course, seldom that two or more motors will show exactly the same curves, and therefore, if the curves are to be of any practical value, several motors should be tested and the representative curve sheet of that particular type of motor should be the mean of the results obtained.

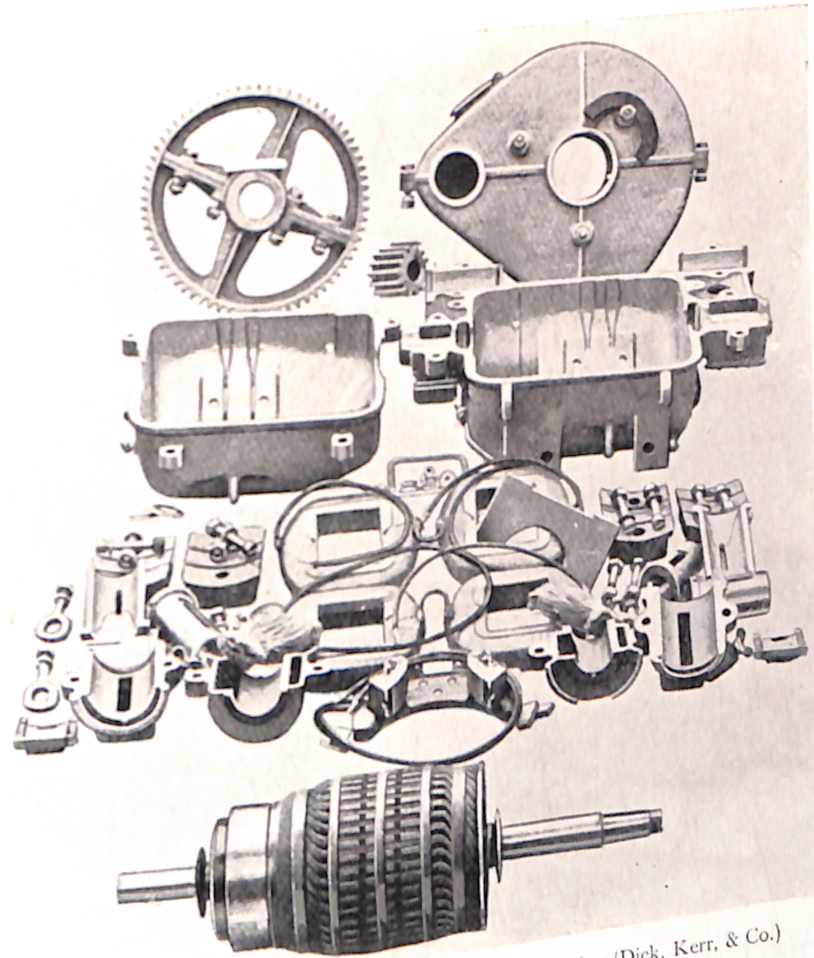

Fig. 215.—Parts of No. 25 Type A Motor before Assembling (Dick, Kerr, & Co.)

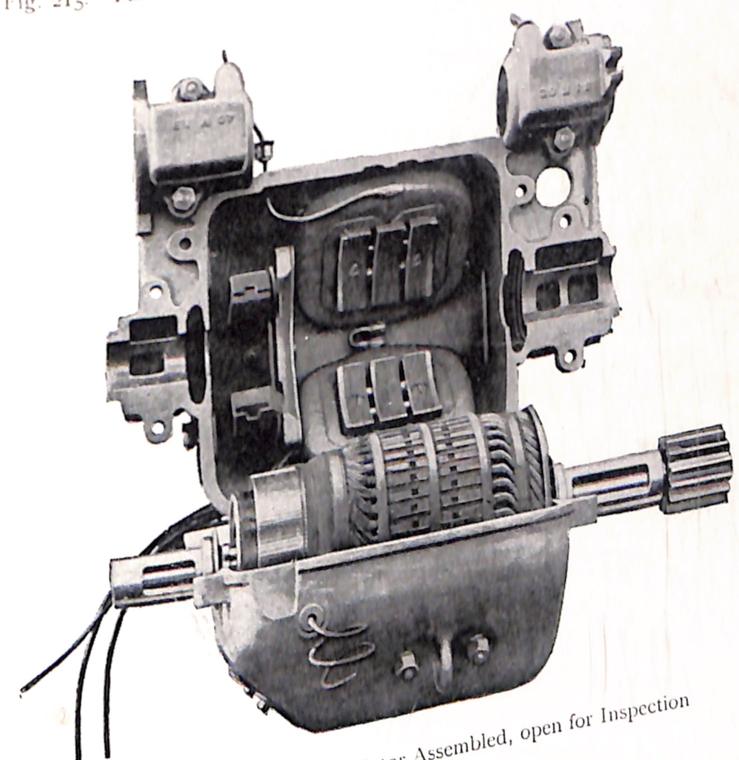

Fig. 216.—No. 25 Type A Motor Assembled, open for Inspection

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The method of drawing these curves is described in Chapter I, "Dynamics of Electric Traction".

Later Types of Tramway Motors.—The most recent types of tramway motors, due to the increased size and weight of the cars, are, naturally, much heavier than the earlier forms, and the introduction of inter-poles has

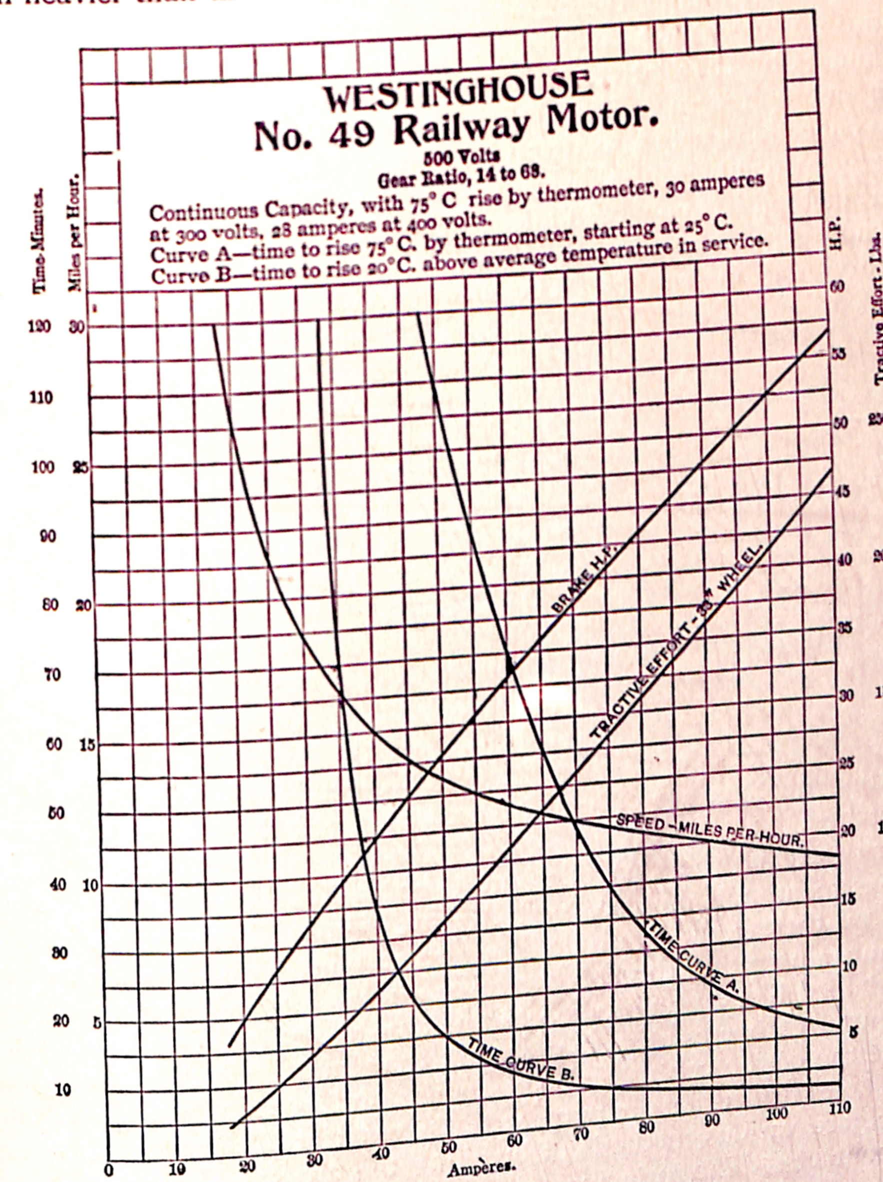

Fig. 218

considerably reduced the sparking at the brushes and consequent deterioration of the commutators. Another improvement consists in slotting out the mica between the commutator segments to a depth of about $\frac{1}{16}$ inch; this prevents the occurrence of "high micas" due to the copper segments wearing down more rapidly than the mica pieces between them, and thus also tends to prevent sparking. To prevent the collection of dirt and copper dust in these slots it is advisable to brush them carefully out every night when the cars are in the depots; it is not found in practice, however, that much trouble arises from such a cause.

Controllers.—We will not enter into a history of the many devices which preceded the modern controller. Suffice it to say that the earlier attempts were based generally upon a rheostatic control only, and one controller situated under the car with its resistances was worked from both platforms by mechanical means. The inefficiency of controlling two or more motors by rheostatic means soon became apparent, and it was then that the more modern series-parallel control was introduced, the diagrammatic connections being relatively shown in fig. 219. This eliminates a very large percentage of the losses hitherto sustained in the resistances, and this method has now been adopted by all makers. It gives two speeds in which no external resistance is in circuit—(*a*) both motors in series, and (*b*) both motors in parallel. These two positions are called the running

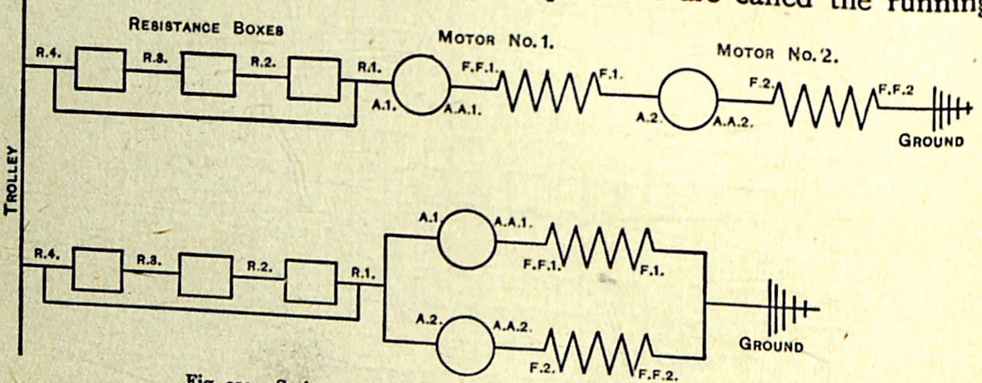

Fig. 219.—Series-parallel Controller Connections on Running Notches

notches; the speeds in which resistances are employed, being termed the accelerating notches, are only to be used to speed the car up to the running notches.

Every part of the controller must be easily accessible for cleaning and adjustment, and must be perfectly fire-proof. Owing to its exposed position on the car, the controller must be absolutely rain-proof. In order to prevent rain getting through the cover where the spindles come through, a ring, shaped like an umbrella, is shrunk on the spindle, and this drains into a gutter of horseshoe shape around the spindle, which in turn drains on to the top of the controller body casting, and from there finds an outlet through holes drilled for the purpose to the exterior of the controller.

There are various methods of breaking the arc so as to avoid damage to the contacts. The principal means employed are either by breaking the arc in a strong field produced by an electromagnet, or in a strong field induced by a series of solenoids situated between the contact fingers. A third method is by breaking the arc in several places simultaneously. We illustrate two representative types of controllers in figs. 220–1. In the case of the magnetic blow-out the magnet is energized during the whole time that the controller is passing current, and the disruptive effect is limited by the permeability of the iron in the core. The solenoid coils are cut out of operation on the two running notches, only

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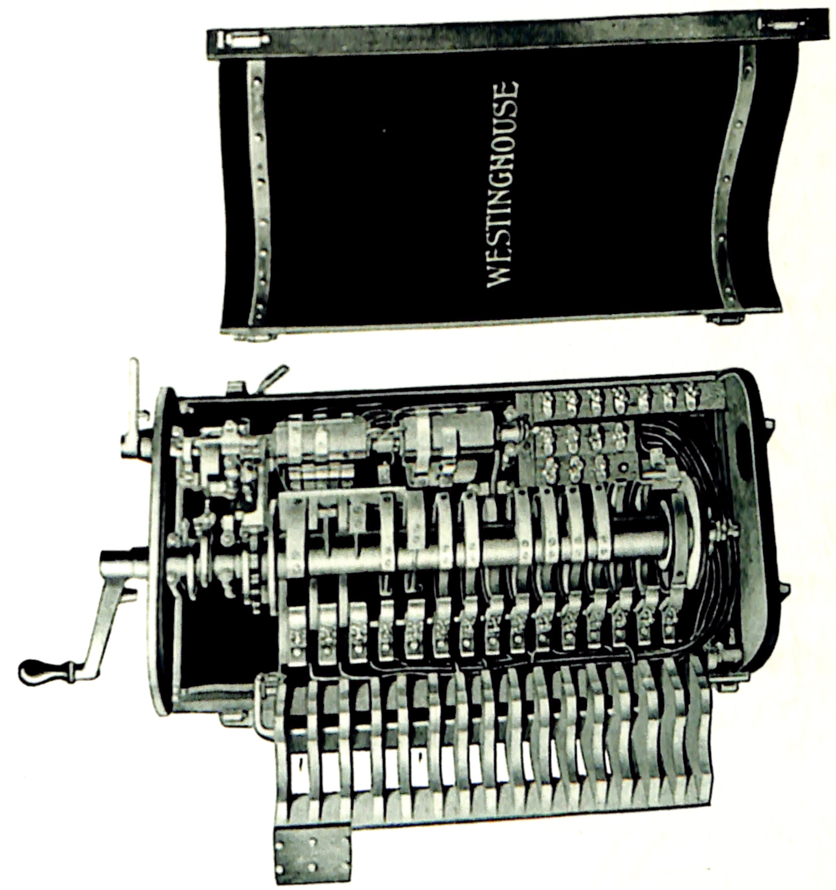

Fig. 221.—Westinghouse Controller No. 90

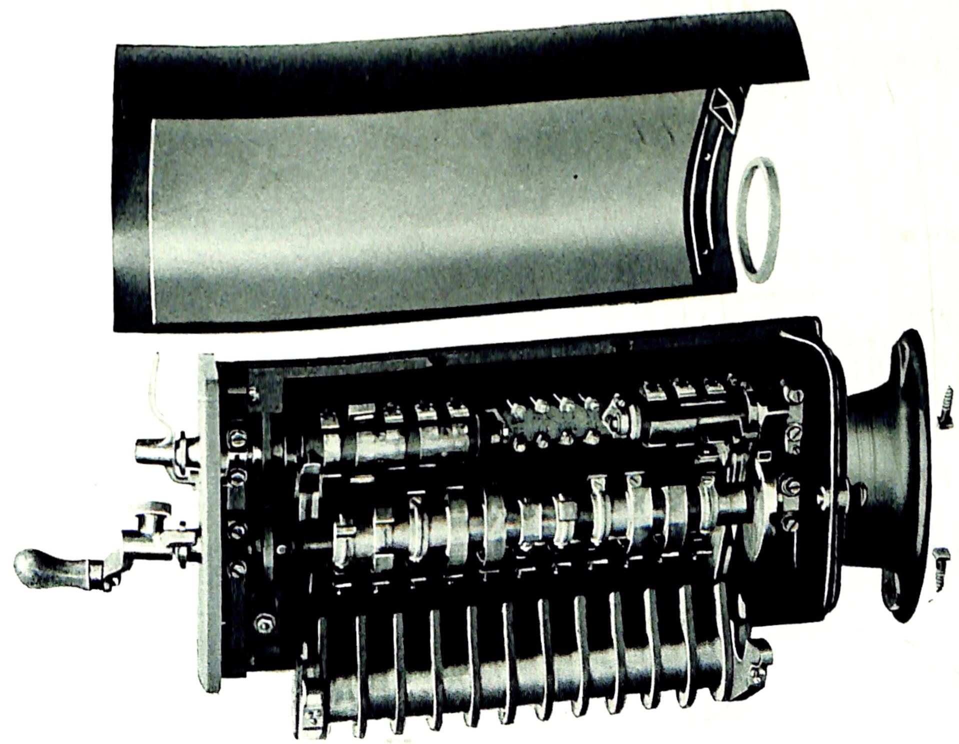

Fig. 220.—Dick, Kerr, & Co. (D. B. 1, form C)

Electric Controllers

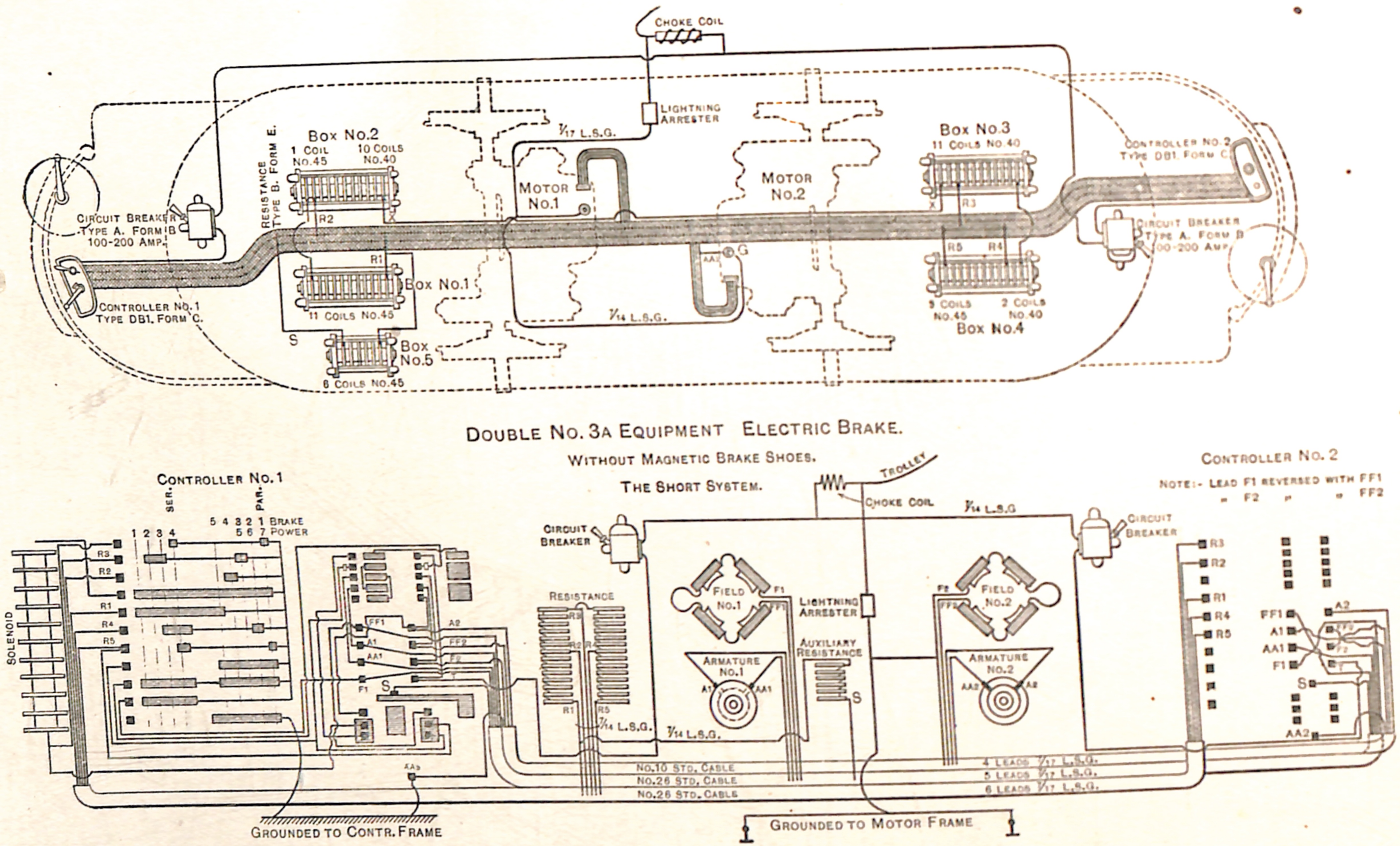

Fig. 222.—Development of Controllers arranged for Electric Braking. D., K., & Co. D. B. 1, form C

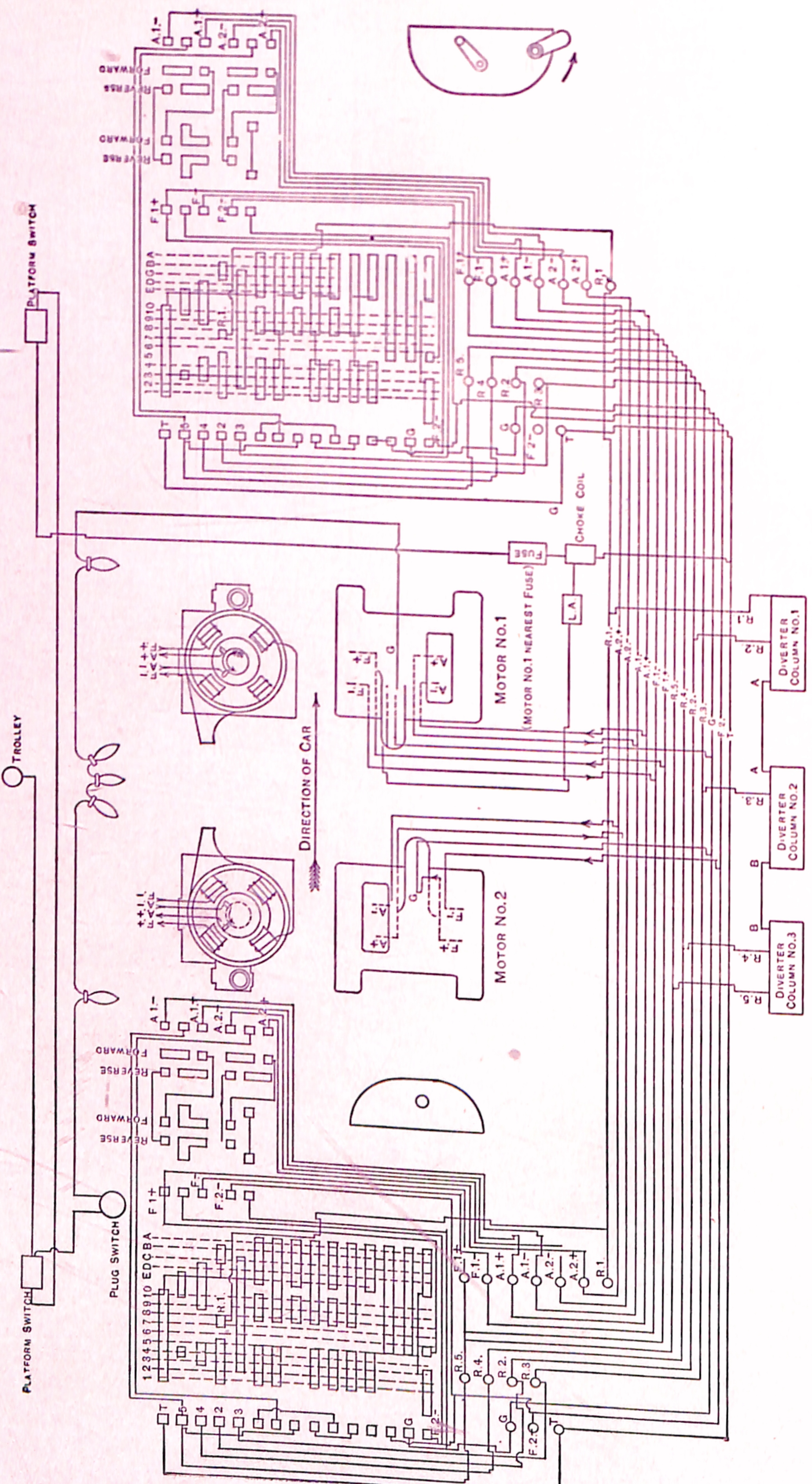

Fig. 223.—Development of Controllers arranged for Electric Braking. Westinghouse, No. 90

being in operation when the current is being broken. This is rendered possible by the instant creation of a field when current passes through the coils, the field being proportional in strength to the current flowing round the coils at the moment of breaking circuit.

We reproduce the wiring diagrams, and development of two well-known types of controllers, from which can be traced the actual connections made on each position or notch, in fig. 222, D.B. 1, form C; fig. 223, No. 90.

It is general nowadays to construct all controllers with a braking arrangement, which we will deal with under the heading of brakes.

The mechanism of the controller should provide that the driving-handle is locked, and cannot be used unless the reversing-handle is at the "ahead" or "reverse" position, and that the reversing-handle cannot be moved unless the driving-handle is at the "off" position. In addition to this, it is a great advantage to arrange that neither handle can be removed from the controller unless it is at the "off" position.

There should be only one pair of handles for each car, and these must be changed from end to end. All handles for the same type of controller should be interchangeable.

Every controller should be so arranged that either of the motors may be cut out of operation, and the car worked on the remaining motor, and this should be done by disconnecting the motor in the controller on the positive side of the armature connection. When cutting it out on one controller it is best, though not necessary, to cut it out on the other at the same time, in case this is forgotten when the other controller is put into use.

In starting the car with one motor it must be remembered that the full voltage is being put across it and the resistance in circuit, and due care in driving must be observed.

Resistances.—Intimately connected with the operation of the motors and controllers are the resistances, or rheostats. A set of car resistances is generally made up for the sake of convenience into two or more boxes, or frames, to facilitate the disposition of them in the rather limited space usually procurable. They are placed under the car framing or platforms, and occasionally under the car seats, in properly fire-proof lined boxes, which must be carefully ventilated. The resistances must be able to withstand vibration, wet, heat, and opportunity for surface leakage must be reduced to a minimum. The design should be such that the heat is quickly dissipated. The material of the conductors should preferably not vary to any great extent in resistance with change of temperature, otherwise a hot resistance will mean an unpleasant and jerky acceleration of the car. Oxidation of the material should not occur under the conditions of service.

Trolleys.—We will next turn to the trolley or collecting arrangement. The type adopted depends on the style of car. For single-deck cars there is very little to be said, and the trolley may be of simplest construction. Fig. 224 shows a trolley of this type, which may be taken as representative of its class.

With either single- or double-deck trolleys it is important that the movement of the arm is free both up and down, and around the central pivot, so that the variations of the line-work may be followed by the trolley-head. Also that the pressure of the head on the line at the varying heights may be nearly constant. The tension employed for centre-running wires may be from 15 to 20 lbs., and for side-running wires from 22 to 26 lbs., measured at the trolley-head at a maximum height of the trolley wire. In order to protect the wire and the guard wires all trolleys should be provided with adjustable stops preventing the head from rising above a predetermined limit.

Considerations concerning the design of the double-deck trolley are somewhat complex. The body and pole of the standard must be carefully insulated from the live conductor, for the protection of the passengers; and as a further precaution the standard itself should be connected electrically to ground, preferably through a device which will indicate if there is any leakage going on. This condition of insulation renders it imperative that no rain should find its way into the pole or standard, and also that there is no possibility of the insulated cable running down the pole and standard becoming chafed, or otherwise mechanically injured.

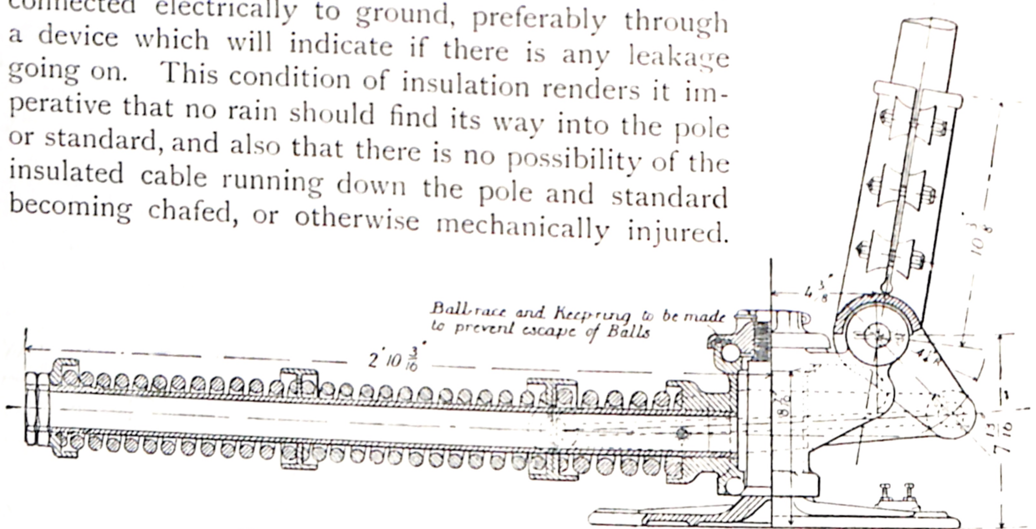

Fig. 224.—Single-deck Trolley Base. Dick, Kerr, & Co., Ltd.

To prevent the cable being twisted a stop is provided, limiting the swing of the pole to nearly one revolution.

To be successful the mechanism of the standard must be easily got at for repairs and adjustment; it must be simple, and of reasonable dimensions. At the present day there are quite a number of different types, most of which may be counted as satisfactory, and we illustrate in fig. 225 (*a*) B.T.H., form B 2; (*b*) Estler; (*c*) Dick, Kerr, & Co., type T.S.; (*d*) Blackwell, type S., a selection of four kinds. Of trolley-heads there are a very large variety, and it would be impossible to note in the space available here one-quarter of them, each possessing some distinctive features of its own. We will therefore confine ourselves to illustrating (fig. 226) an example of the straight-running type of simple design.

The trolley wheels should be of moderate diameter, and grooved to suit the size of wire and type of frogs, crossings, &c. They can be fitted with removable bushings filled with graphite, which may be replaced several times during the life of the wheel. Precaution in designing is sometimes taken to prevent the rim falling off when the wheel is badly worn. Radiat-

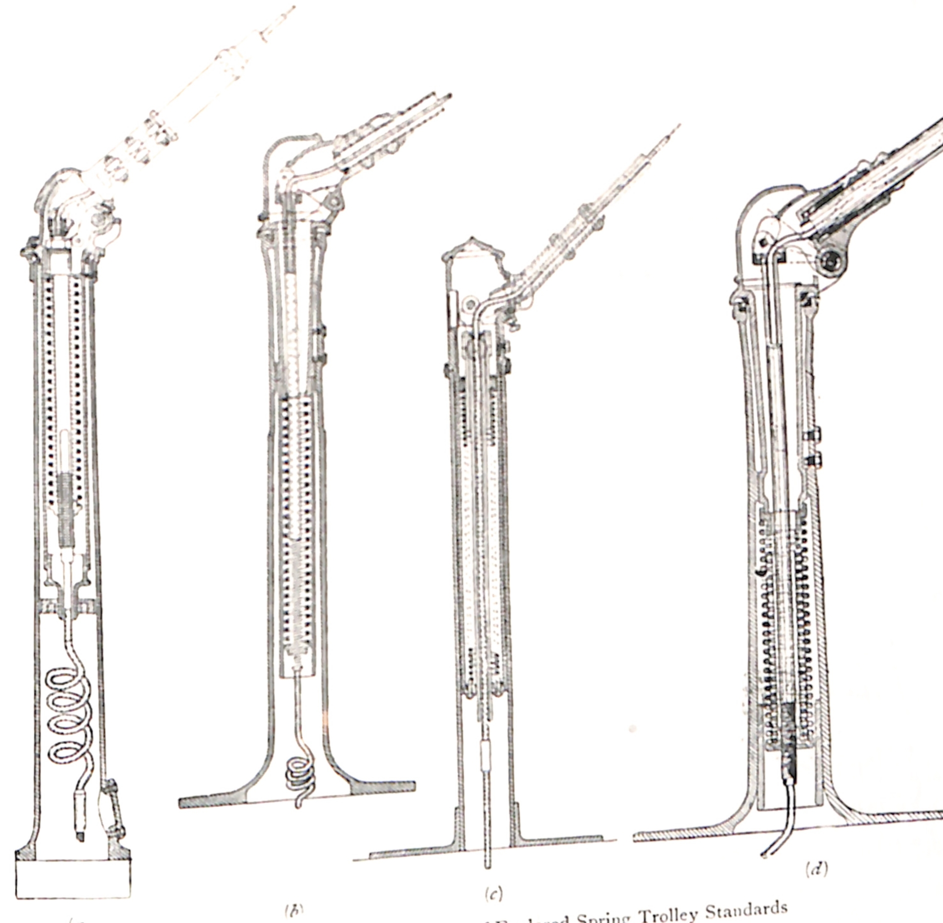

Fig. 225.—Various Types of Enclosed Spring Trolley Standards

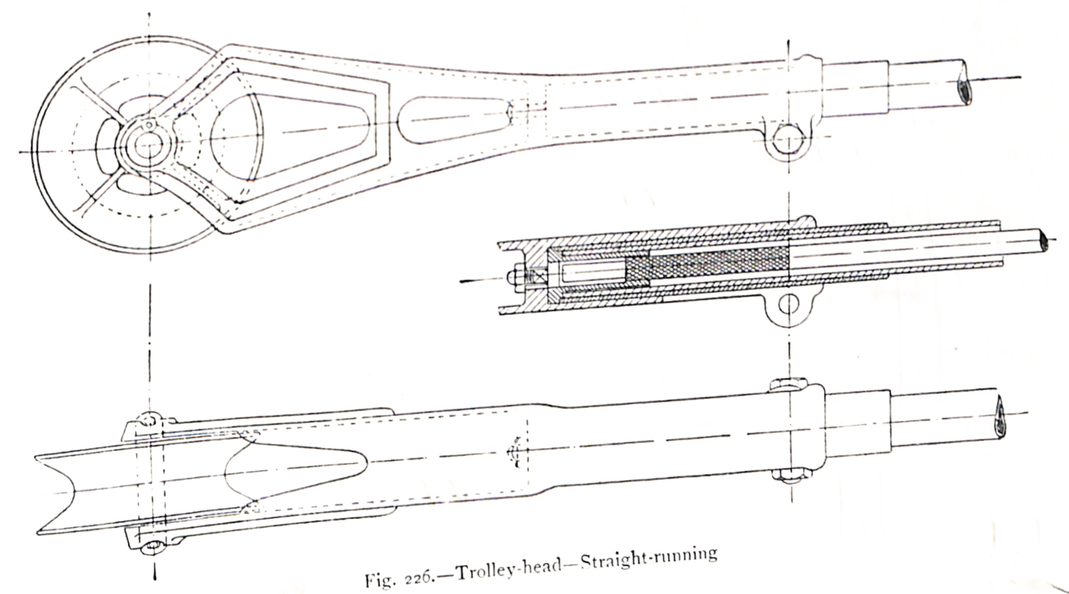

Fig. 226.—Trolley-head—Straight-running

ing webs from the boss to the flange are cast on the wheels, and these effectually prevent the flange from falling.

Accessories.—Each equipment should be furnished with two main switches for breaking the current in case of emergency, and for the general

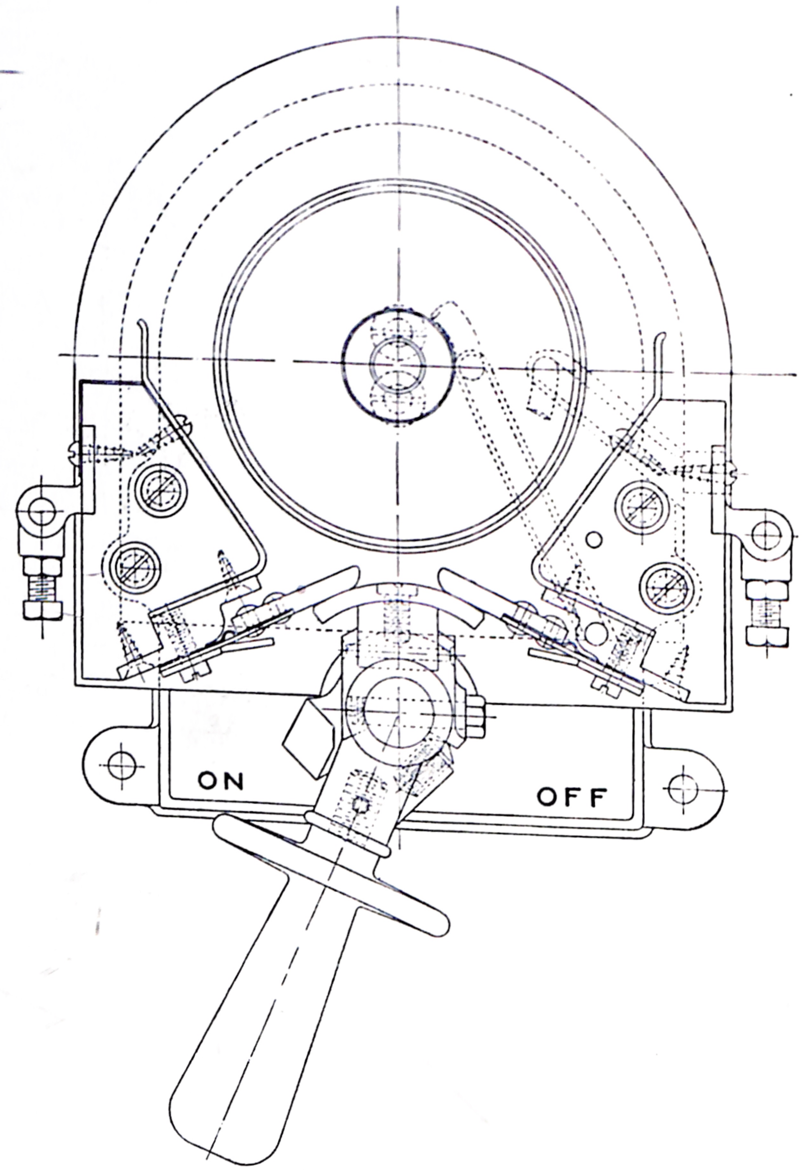

Fig. 227.—Dick, Kerr, & Co.'s Circuit-breaker, Type A. 60, from D

protection of the shed staff when cleaning or adjusting the controllers, &c. One of these should be placed at each end of the car within easy reach of the motorman. It is advisable that one of these switches shall be automatic in action, so as to cut out at any predetermined load.

Both switches should be preferably fitted with an arc-breaking device, and they should certainly be able to break without damage any current

likely to be passed through them. We illustrate an automatic circuit-breaker with metallic-shield solenoid blow-out in fig. 227.

It is not a necessity, where an automatic circuit-breaker is employed, to have a main fuse in circuit, but it is certainly an additional safeguard, and is recommended. The fuse inserted should be of sufficient capacity, so that it will not blow unless the circuit-breaker has by any chance got out of order.

The car cabling, connecting the motors, resistances, and controllers together, should be made up in one or more bundles, having taps made at the most convenient positions for connection to the motors, &c. The joints must be carefully made, and well insulated. The cabling, if not made up in multi-core cable, as is the practice of Dick, Kerr, & Co., Ltd., of Preston, should be enclosed in stout hosing, and should be bound up at the exit of the taps and ends with stout tape, and treated with water-resisting compound. In fixing the cables in the cars they should be run when possible under the longitudinal seats, held against the car sides by

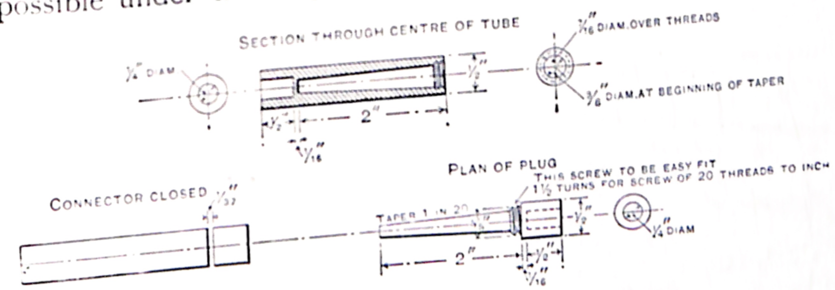

Fig. 228.—Patent Screw-cone Connector

leather slings; they should not be placed on the car floor, as this interferes with the sweeping out of the car, and collects the dirt and dust. At the end of the car body they should pass through the flooring and travel along the end-sills till opposite the bottom of the controller, and then be run along a platform-bearer to the hole provided for leading them into the controller.

Some engineers favour the idea of using junction-boxes for the connections between the cabling taps and the motor taps. The ordinary four-screw connector answers the purpose quite well when carefully insulated with rubber and friction tape.

An ingenious connector which has proved of great practical value is illustrated in fig. 228, and is known as the screw-cone connector. It ensures good electrical contact, is easy to fasten and unfasten; it has no metal screws projecting, which sometimes cause trouble by chafing through the insulation.

Lightning-arresters should be provided on all trolley-cars; but in the case of conduits or surface-contacts and storage systems they are unnecessary. They should be capable of dealing with repeated discharges without attention or readjustment.

The choking coils, which resist the passage of all oscillatory discharges, should be mounted in series with the car trolley-conductor, and the arrester should be connected on the trolley side of the coil, the other terminal being electrically connected to the rail or earth connection.

Brakes and Braking.—The question of brakes is certainly a most important one, and should be regarded by engineers as of quite equal moment to the means of propulsion.

It should be the aim of all engineers to have the brakes simple in design, positive and certain in action, and capable of rapid application. Each brake on a car should as far as possible be a separate unit, depending in no way upon any other of the brakes, so that if one becomes inoperative it in no way affects the operation of the others.

The Hand-brake.—The ordinary hand-brake, worked from either platform by a ratchet handle or hand-wheel, is applied to nearly every car constructed. The manner of applying the shoes to the wheels varies more or less with each type of truck, and reference should be made to the illustrations we produce of truck construction. Provision must be made for easily adjusting the wear to the shoes (during service if necessary) and for the automatic equalization of the pressure of each shoe. The shoes should be capable of being removed and new ones fixed on with a minimum of trouble.

A ratchet handle is preferable to a hand-wheel, as taking up less room on the platform, and enabling the brakes to be applied more quickly. If the handle comes to an awkward position it may be pulled back, the spindle being held by the foot-dog provided for that purpose, till it is in a position of greatest convenience for the motorman. The brake spindle which projects down through the platform floor is attached to the truck levers by a rod and chain; it is advisable that this chain, which winds on the spindle, should be supplemented with another to take up the strain if the working chain breaks. There should always be as little slack on the working chain as possible when the shoes are free, as much time is taken up in winding the slack on the spindle before the shoes come into operation. The leverage of the brake rigging should be such that a man of average strength can effect a total pressure on the whole of the brake-blocks of 100 per cent of the weight of the car unloaded.

Slipper Brake.—In addition to the hand-brake it is imperative to have another means of retardation. In cases where there are few hills to be negotiated, and none of them severe, it is sufficient to provide an electrical emergency brake hereafter described. Under ordinary circumstances the hand-brake should be sufficient to control the car, and the auxiliary brake may be considered merely as a stand-by. Where there are long and dangerous hills, however, it is advisable to adopt also some form of track brake or slipper brake acting by direct pressure on the rails. The ordinary hand-worked slipper brake entirely fulfils the purpose for which it is required, namely, for retarding the car down steep or long gradients. It is usually operated by a hand-wheel mounted on each platform, either concentric with the hand-brake spindle or beside it.

Pneumatic Slipper Brake.—An ingenious combination of the air brake and the slipper brake, known as the Hewitt & Rhodes brake, is illustrated in fig. 229. The advantages of this claimed over the hand-worked brake are: (*a*) instantaneous application and release; (*b*) cushioning effect of the air upon the slippers; (*c*) saving of labour and fatigue to the driver; (*d*) positive and sure action; (*e*) small number of working parts. The shoes are pressed on to the rails by direct air pressure, the release being made by means of springs, which lift the shoes from the rail when the air pressure is reduced.

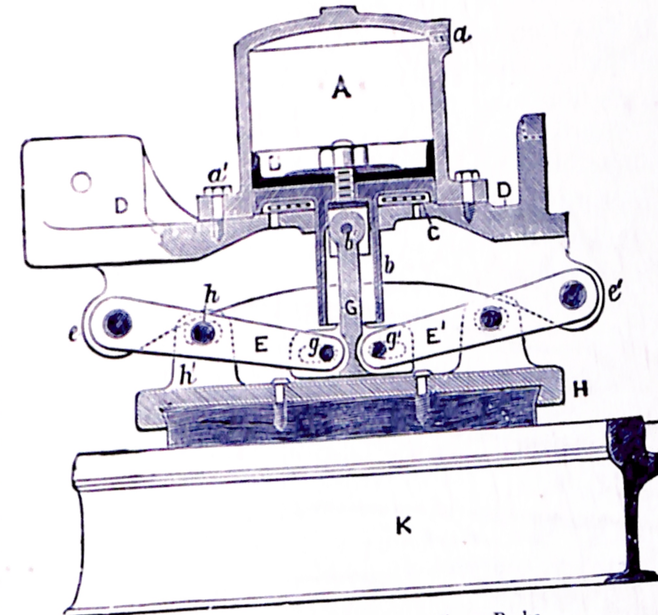

Fig. 229.—Hewitt & Rhodes Slipper Brake

The Electromagnetic Slipper Brake.—We illustrate this brake in fig. 230, as involving quite a novel feature in brake design. The facility with which this brake may be attached to any standard truck will be clear from the illustration. In action it derives its power from the car motors acting as generators, which are made to rotate by the momentum of the car, using the energy thus obtained for exciting the magnets operating the track and the wheels' shoes. There are three sources of braking involved, namely: (*a*) the

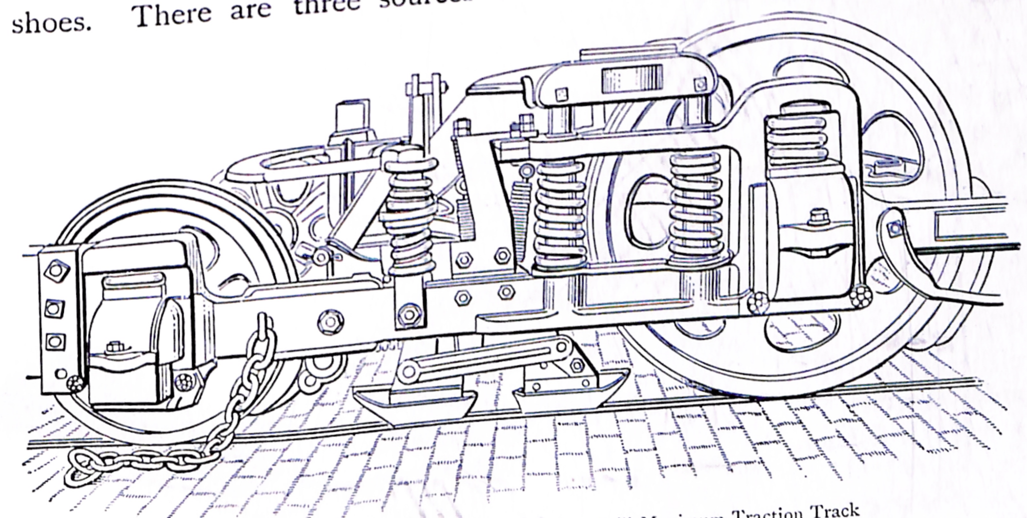

Fig. 230.—Electromagnetic Brake attached to Brill Maximum Traction Track

adhesion of the slippers to the rail; (*b*) the pressure of the brake shoes on the wheels; (*c*) the retarding effect on the car axles by the load on the motors.

Electrical Emergency Brake.—The emergency brake, as its name implies, is only adapted for use in cases of emergency; the stop produced is very severe on the car, equipment, and passengers. The brake is put into operation by shutting off the controlling handle, and pulling the small reversing handle on to the emergency notch, marked on the controller cover, taking care that the handle always passes through the "off" position. That is, if the car is moving forwards the handle must be pulled to its utmost extent towards the motorman, and if the car be travelling backwards the handle must be pushed away from the driver. Fig. 231 shows the connections of this brake diagrammatically. The forward or backward position of the reverse handle (according to the direction of motion of the car) merely crosses over the armature connections, so that the induced current in the armature may flow round the field windings in a direction to assist the residual magnetism of the poles, and thus build up the E.M.F. of the motors. The product of the E.M.F. and the resultant current flowing round the circuits being practically the watts absorbed in braking the car. By the very nature of the device the braking effect upon the wheels is proportional to the speed of the car, and if on a greasy track the wheels skid, the brake at once releases for the moment, a result highly desirable, as with a resumption of rotation the brake is again brought into action. Owing to there being no external resistance in circuit the motors quickly attain their maximum E.M.F. for the speed they are running. The brake must never be released until the car has come to rest, as there is no provision for blowing out the arc caused by breaking the current which is flowing. The brake should be applied with the wheel brakes free, and as the car comes nearly to rest the hand-brake should be screwed on to hold the car at rest, and the emergency brake then released. From the diagram produced it is entirely evident that this brake is quite independent of the trolley-wire current. No brake which is dependent upon the trolley-wire current can be of the slightest practical use.

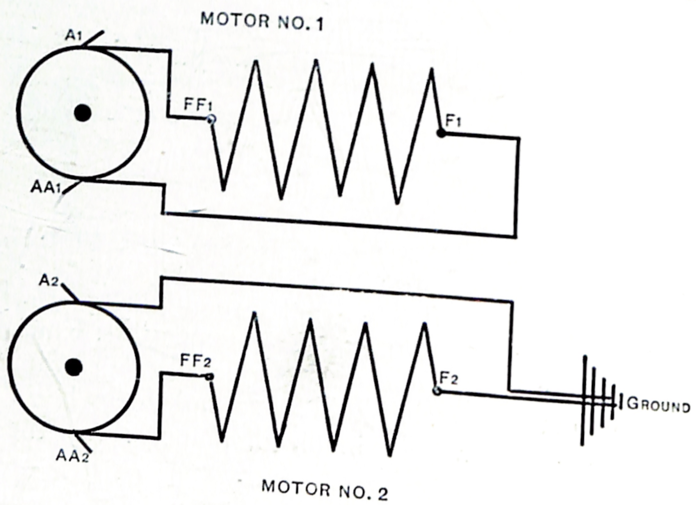

Fig. 231

Rheostatic Electrical Brake.—This type has found much favour with the tramways in this country, and for general utility and convenience it is highly attractive. In principle it is identical with the emergency brake just described, but is operated by the driving-handle of the controller, and not the reversing-handle, and is provided with graduating notches, similar to the driving notches, for regulation. The brake is applied by

swinging the driving-handle to the "off" position, and continuing the motion on to the brake notches. There are usually four or more brake notches, each representing a certain amount of external resistance for regulating the effect as desired; an arc-breaking device is provided, so that the brake may be taken off or adjusted from notch to notch without damage to the contacts. Should a car be standing on an up-grade and the hand-brake fail, the electric brake may be employed to stop the backward motion by bringing the driving-handle to the "off" position and pulling over the reversing-handle, as if driving the car backwards, and then operating the driving-handle on the brake notches. Pulling over the reversing-handle makes the change of connections to the armature leads rendered necessary by the reversal of the direction of the armature rotation.

Air Brakes.—Air brakes for tramway purposes are nearly all worked upon the "straight" air system, as distinctive from the "automatic" air systems employing a triple valve as used on the railways, where the length of the train and necessity for instantaneous application upon all the coaches at once renders the straight air system unsatisfactory. The straight air system will operate one or two trailer cars quite successfully. The brakes are generally made to act upon the same blocks as the hand-brake, and in order to provide for the free operation of the hand-brake the cylinder is so designed that when using the hand-brake the piston is not moved along the cylinder; this is managed by making the piston-rod end abut into a cup-shaped cavity in the piston, to which it is not actually attached. The cylinder is single-ended, and the piston is returned to the head of the cylinder upon release of the compressed air by a suitable spring.

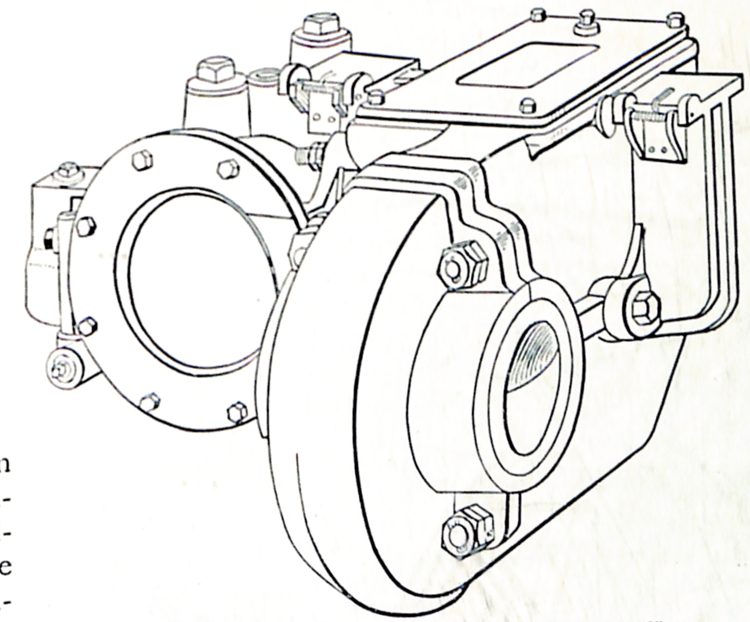
Fig. 232.—Westinghouse Brake Company's Geared Compressor

The systems usually employed upon tramway-cars may be divided into three headings, as follows: (*a*) axle-driven compressors; (*b*) motor-driven compressors; (*c*) storage. A short description of the leading features of each may be of interest. (*a*) The compressors are either of the geared type (see fig. 232) or are eccentric-driven; in each case they derive their power from the car axle, and deliver the air into suitable reservoirs provided for the purpose. The compressors are specially designed to allow of their

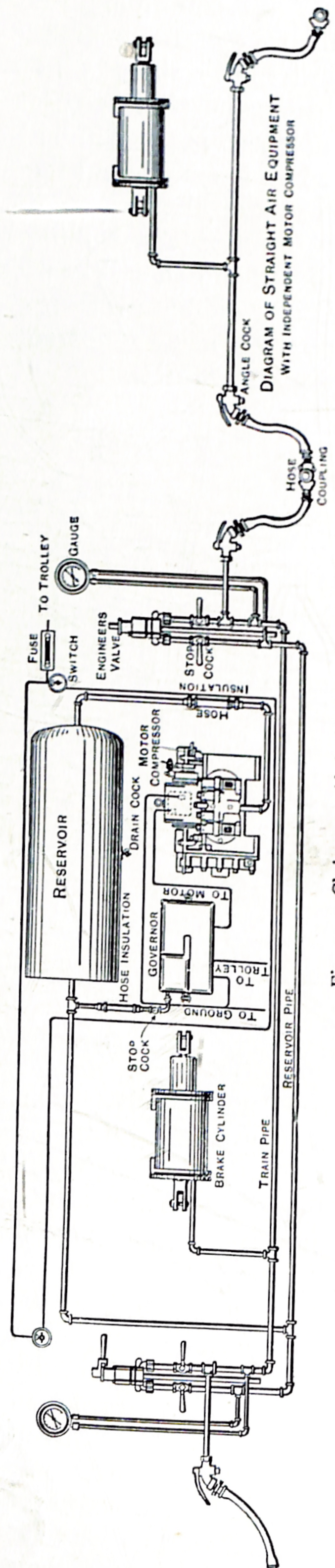

Fig. 233.—Christensen Air-brake Equipment

being attached to the axle in the space left between the motor axle bearing and the wheel hub. The compressors should be furnished with automatic control, so that they will cut out of, and into, operation at any predetermined maximum and minimum pressure in the reservoir. The reservoirs should be fitted with a safety-valve of sufficient capacity to deal with the air should the compressor cut-out fail to act. It should also be fitted with a draincock to draw off the water condensed from the atmosphere. The air from the reservoir is passed straight to the brake cylinder through the operating or service valve, one of these being situated at each end of the car, the exhaust from the cylinder being sometimes passed through a muffler. On certain types of compressors the exhaust air is made to lift the compressor valves, and so for the first few yards at starting up relieve the motors from extra duty. Whatever type of compressor is adopted it must be quite dust-proof and self-lubricating, and absolutely automatic in action, its position on the car necessitating the first two conditions and the latter being essential for street tramway work, where all the motorman's attention is required to pilot his car in safety through the traffic. (*b*) For large cars, and in cases where there is no room on the car axle, a motor-driven compressor is used. The motors are, of course, built for the 500-volt tramway circuit. An automatic switch controls the operation of the motor compressor, so that the reservoir pressure may be kept nearly constant; this switch should be capable of being operated by hand if required. Fig. 233 shows the general arrangement of a Christensen motor-driven air brake. (*c*) The storage system, as the name implies, requires sufficient reservoir capacity for making the necessary number of stops between the stations where the reservoirs may be replenished. The system shows to best advantage where the stops are scheduled and intermediate stops infrequent.

Air brakes in general are an expensive item of a car equipment, and the advantage of their adoption on small cars running without trailers is questionable. They apply the shoes more

quickly than does the hand brake, and for heavy cars they undoubtedly are of great benefit. In cases where trailers are in general use they offer advantages over braking by hand, as by the simple attachment of a hose-pipe and coupling at each end of the cars and trailers, and the addition of a brake cylinder to each trailer, the brakes of the whole train of two or more cars may be controlled from the front platform. When trailers are used additional reservoir and compressor capacity must be provided, and in calculating the amount of air used for each application it must be taken into consideration that the pipe connections from the service valve to the cylinders are for each application filled with live air, and are exhausted with the cylinders on the brakes being released. Pressures of over 50 lbs. per square inch are unusual, but when met with are generally obtained

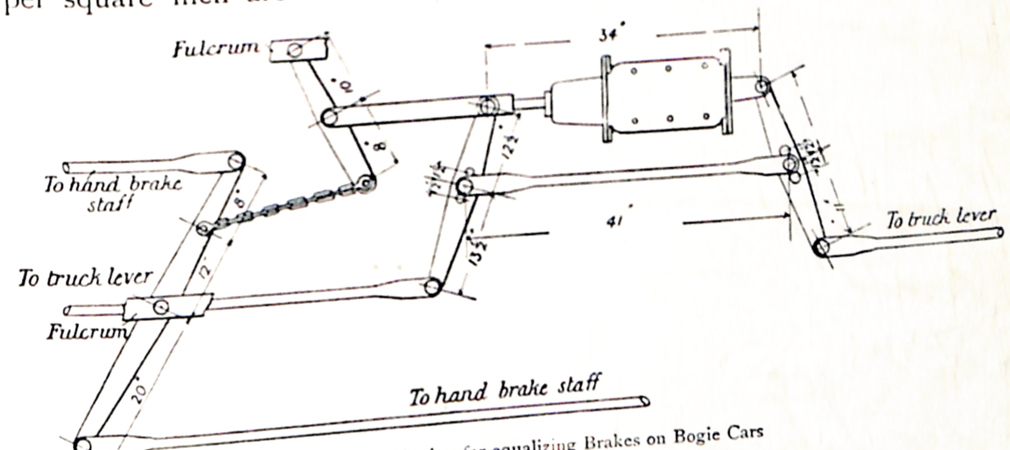

Fig. 234.—Rigging for equalizing Brakes on Bogie Cars

by compressing in two stages, and compound compressors are built for this purpose.

Fig. 234 shows a very efficient style of brake rigging employed by the Westinghouse Brake Company for use on double-truck cars, ensuring the equalization of the braking power on both trucks.

Sanding Arrangements.—With self-propelled vehicles the question of sanding the rails assumes a far more important aspect than in the case of horse cars, where a box of wet sand is hung on the dash to be strewn on the track by hand when required. It has been recognized that dry sand fulfils its purpose better than wet, as it tends not only to give a grip owing to its gritty nature, but also dries the track. It would be impossible to scatter dry sand in the old way, as it would be blown away, and therefore proper sand-hoppers are fitted to the cars with the delivery-pipes leading right down to the rail head. The sand used should be sharp and gritty, and before being placed in the car hoppers should be thoroughly dried, for which special ovens are generally constructed in the car depot. When the sand is derived from the seashore it is sometimes necessary to wash out the salt, as, even after baking, in damp weather it will absorb moisture and clog the sand valves. We instance two well-known types of sanding-gear: the Ham, representing an intermittent-flow type; and the Common-sense, the continuous-flow type. The hoppers are worked from the platform by the motorman's right foot pressing on a plunger. With the continuous type, as long as the plunger is depressed the sand will flow; thus it has the advantage of giving an even distribution of sand along the rail; but there is always the danger of the valve becoming stuck by a small pebble getting in the way of it closing, and allowing the sand to slowly escape unknown to the motorman. In the case of the intermittent type the motorman presses and releases the plunger alternately; this pumps the sand on to the rail with fairly even distribution. It is now becoming quite general to place four hoppers on each car, and so sand both rails. The older and more usual practice was only to sand the off-side rail, leaving the other clean for

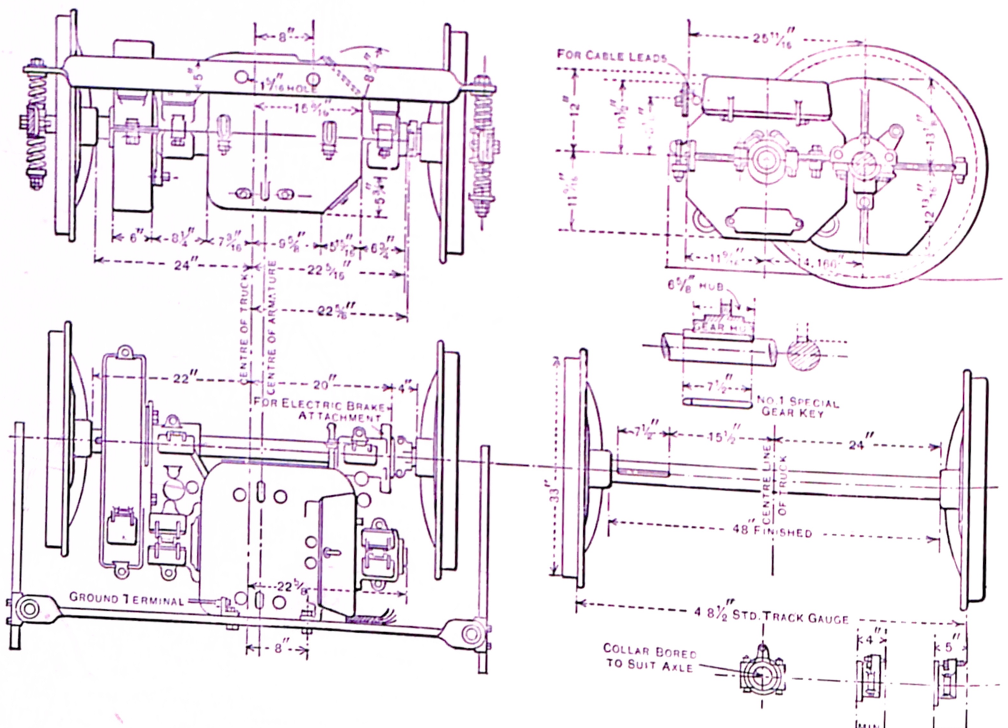

Fig. 235

the necessary electrical contact. It is advisable, if four hoppers are to be employed, for the off-side and near-side boxes to be worked by separate pedals, placed near enough together so that the motorman can cover both with his one foot if necessary. On large cars where air brakes are used, sand is sometimes served to the rail by means of an air blast; the practice is, however, exceptional.

Car Trucks.—The car trucks for electric-traction purposes must be designed not only to carry the car body and to give it an easy riding motion, but must also provide for the suspension of the motors in such a manner that they are subjected to a minimum of vibration. The tractive effort exerted by the motors is transmitted from the car axles to the axle-boxes, and from these to the truck side frames. The side frames are separated from the top bars by a system of springs, and it is through these springs that motion is imparted to the car body, which in the case of single-

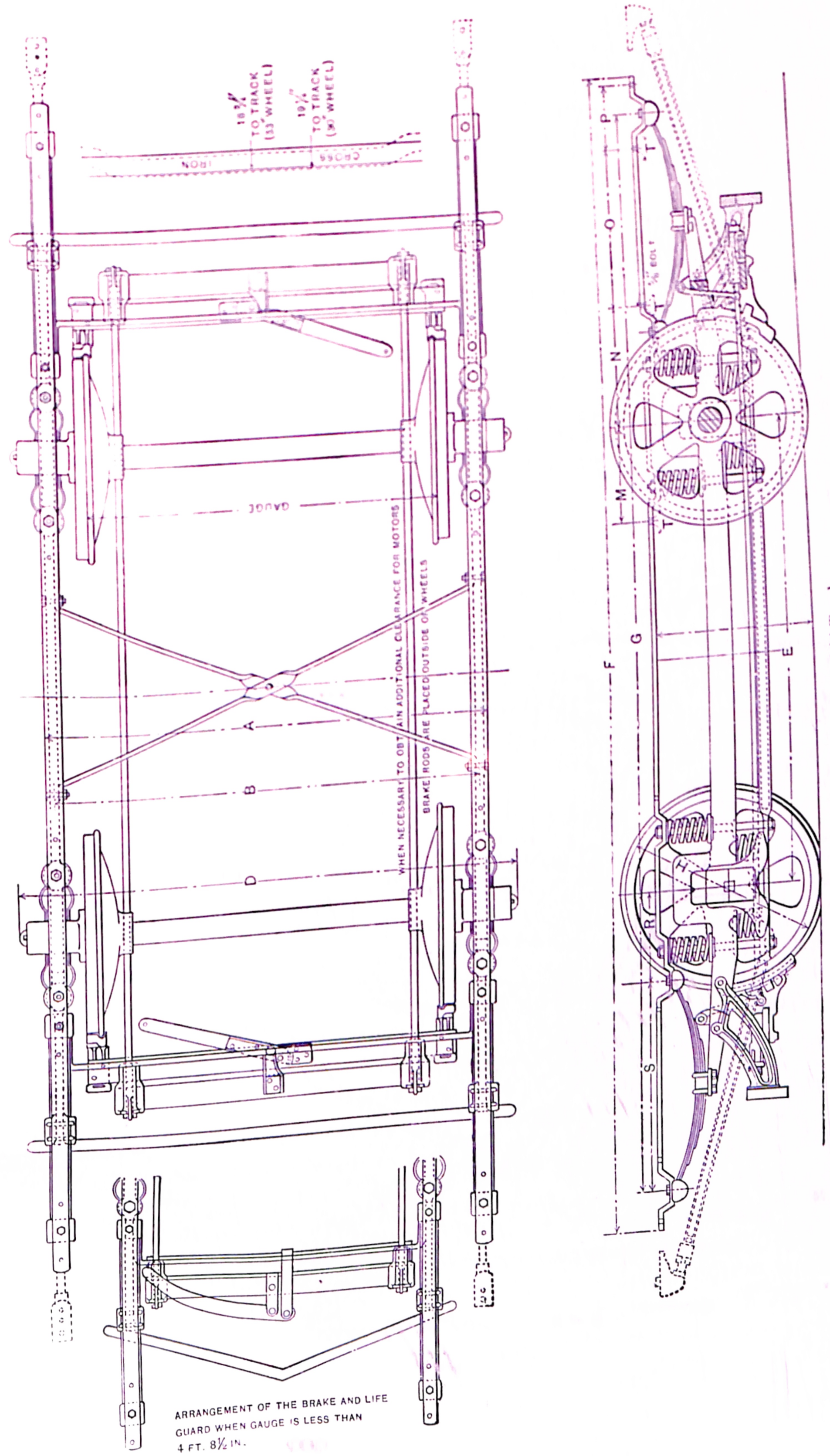

Fig. 236.—Standard Brill Truck

truck cars is bolted to the truck top bar. It will be seen, therefore, that the springs must not only ensure the easy riding of the body, but must withstand the horizontal strains of rapid acceleration and retardation without undue pitching.

The most usual method of suspending the motors is by carrying a large percentage of the weight of the motor direct on the car axle through the motor axle-bearings, the back end of the motor being provided with a bracket or other means of attachment to a cross-bar supported on the truck side frames entirely on springs. This method is shown in fig. 235, and is known as the "Nose" suspension.

Trucks may be divided primarily into two distinctive classes, namely, the rigid four-wheel truck and the bogie or swivelling truck. The latter class may be again subdivided into maximum-traction and equal-traction types.

Rigid Four-wheel Trucks.—This type, owing to the popularity of the short double-deck car, is considerably in the majority, and is suitable for carrying such car bodies up to about 20 feet or more with easy riding, though the majority of trucks are carrying cars of 15 feet 6 inches to 16 feet 6 inches over the corner posts, in which case the wheel base, or distance between the axle centres, is not necessarily more than 6 feet. Wheel bases most commonly met with are 5 feet 6 inches and 6 feet, and in some special cases 5 feet, 6 feet 6 inches, or 7 feet are adopted. It is advisable to keep the wheel base as long as can be comfortably worked with the curves to be rounded. It is evident that the longer the wheel base the greater will be the difficulty in rounding curves. It may be taken that a 6-foot wheel base will round with comfort a curve of 35 feet radius, and can even be run on sharper curves than this if it is found necessary. No hard-and-fast rule can be laid down, as a great deal depends upon the section of the rail employed and the profile of the car wheels.

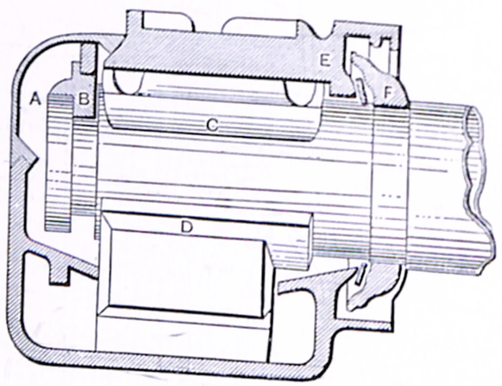

Fig. 237.—Section of Brill Axle-box

The trucks should be cross-braced in such a manner that when rounding curves or taking points they are able to withstand the consequent strains without racking the car underframing.

We illustrate in fig. 236 a standard Brill No. 21 E single truck. It will be noticed that the side frames are of one piece, this being a speciality of this particular make, and the manufacturers claim for this construction immunity from depreciation due to the incessant strains and blows, which in a built-up side frame have to be withstood by the bolts and rivets, &c., holding the members together. Extension rods are provided with this truck for use with extra long car bodies. We reproduce an illustration (fig. 237) of the Brill axle-box in section; this box may

be used either for grease lubrication or for oil with equal facility. It is necessary that the journals shall be self-lubricating, and shall require no attention other than the periodical refilling and occasional inspection. The box is provided with a cover easily removable from the outside, and the check plate, or thrust collar, and the saddle brass may be removed for examination by relieving the pressure of the car weight by means of a small jack inserted under the truck frame. The outside of the axle-box casting is provided with two wings on each side of the base on which the truck side frames rest supported on spiral springs. The axle-boxes should fit into the horn plates of the side frame with plenty of clearance, and the boxes should be free to ride up and down the horn plates.

The connection in the Brill 21 E truck between the side frames and the top plates are made by four spiral springs and two semi-elliptical springs each side of the truck, the elliptical springs being placed at the extremities of the spring base, their function being to steady the action of the spiral springs, which otherwise would allow the car to get up a rhythmic pitching or oscillatory motion.

The Peckham four-wheeled truck is an example of the built-up side-frame class, and has met with considerable appreciation. The construction is on the cantilever principle, and to follow this out it is necessary that the horn plates have filling pieces made to fit tightly in under the axle-boxes, and to remove these, for rewheeling the car, it is necessary to spring open the horn plates slightly. In the Peckham truck the weight of the car and truck side frames is taken on the top of the axle-boxes, springs intervening.

Maximum-traction Bogie Trucks.—We will first deal with that class of bogie truck known as the maximum-traction truck. These trucks are designed for use where circumstances will not permit of the use of rigid four-wheel trucks, and where two motors only are required on each car. The use of double trucks, in general with their short wheel base, this being usually only 4 feet, greatly facilitates the rounding of curves which could not safely be negotiated with single trucks and longer wheel bases. Generally speaking the driving-wheels are 30 inches or 33 inches in diameter, while the pony or trailing wheels are 20 inches in diameter.

It is obvious that if a car mounted upon eight wheels, each of which is taking an equal share of its weight, is only driven on four of the wheels (i.e. two axles), the weight for traction obtained will only be half of that had the car been mounted on a four-wheel truck; this is of course eliminating any consideration of that portion of the weight of the motors which comes direct on the driving-axles. Consequently it is perfectly clear that an equal-traction bogie car, unless provided with four motors, one on each axle, is not desirable.

The arrangement of the maximum-traction truck allows of 75 per cent to 80 per cent of the car weight coming on to the driving-wheels, to which must be added a greater portion of the weight of the motors, so that only from 20 per cent to 25 per cent of the weight of the car, and a small portion of the weight of the motors, is lost for traction purposes. This small amount is that which is necessary to compel the pony-wheels to keep the track. This device is a considerable improvement upon equal-traction trucks, but it must never be expected that a maximum-traction truck car will mount steep grades, and descend with the same amount of safety and ease as a four-wheel truck which employs every ounce of its weight as useful traction. Where large cars are to be worked, and steep grades are met with, there is no doubt a four-motor car is advisable.

As only a small portion of the total weight comes on the pony-wheels of a maximum-traction truck, it is necessary that the wheel-brake pressure is divided in the same proportion, or else the pony-wheels would skid before the full braking effect was reached on the driving-wheels. We illustrate in fig. 238 a Brill "Eureka" maximum-traction truck, and it will be seen to gain this end the pressure on the pony-wheel shoes is transmitted through adjustable springs.

Bogie trucks generally, unlike the four-wheel rigid truck, are not bolted to the car body in any way, but the body rests on two rub-plates, one on each side of the truck. In the case of the Brill maximum-traction type the rub-plates are supported from the truck side frame by two spiral springs and spring posts, and fit into corresponding angle plates of the same radius attached to the car body, and all these are concentric to the pivotal point of the truck, which is located about 6 inches from the central point of the driving axle in the direction of the pony axle. The thrust of the truck on the car body is taken on a king-pin attached to the car framing, which projects through a suitable motion block running in a radial slide, as shown in the illustration. The truck is also furnished with a compression device consisting of a plunger supported by a heavy spiral spring, which latter is capable of adjustment; the plunger, pressing upwards, bears on a metal plate affixed to the car underframing, shaped so that the compression is least when the car is on the straight track. It is by this compression device that the percentage of weight upon the pony-wheels may be varied to a considerable extent by adjustment. The illustration we produce shows this compression device separately in section.

The brake-rods, in the case of trucks for 3-foot-6-inch and 4-foot gauge, are placed outside the wheels, this also being the case with single-truck cars, and in special instances on the standard 4-foot-8½-inch-gauge trucks where rendered necessary for clearance required for air-brake compressors or other auxiliary gear.

The brakes on the two trucks are connected to a cross-beam attached to the underframing of the car, to the extremities of which are attached the pull-rods and chains connected to the brake spindles on the platforms. By means of short chain connections and pulleys it is arranged that the braking pull on each truck is equalized from the cross-bar. In order to provide for the swing of the truck on curves, the connection between the cross-bar and each truck brake rigging is made by radial yokes, and the pull-rod ends are provided with small friction-wheels running in the yokes. This ensures that the brakes are not dragged on when the car rounds any curves, which otherwise would be the case; this is clearly shown in the illustration. As seen from the same illustration the motor is to be located between the two axles, the arrangement of suspension being almost identical with four-wheel single trucks.

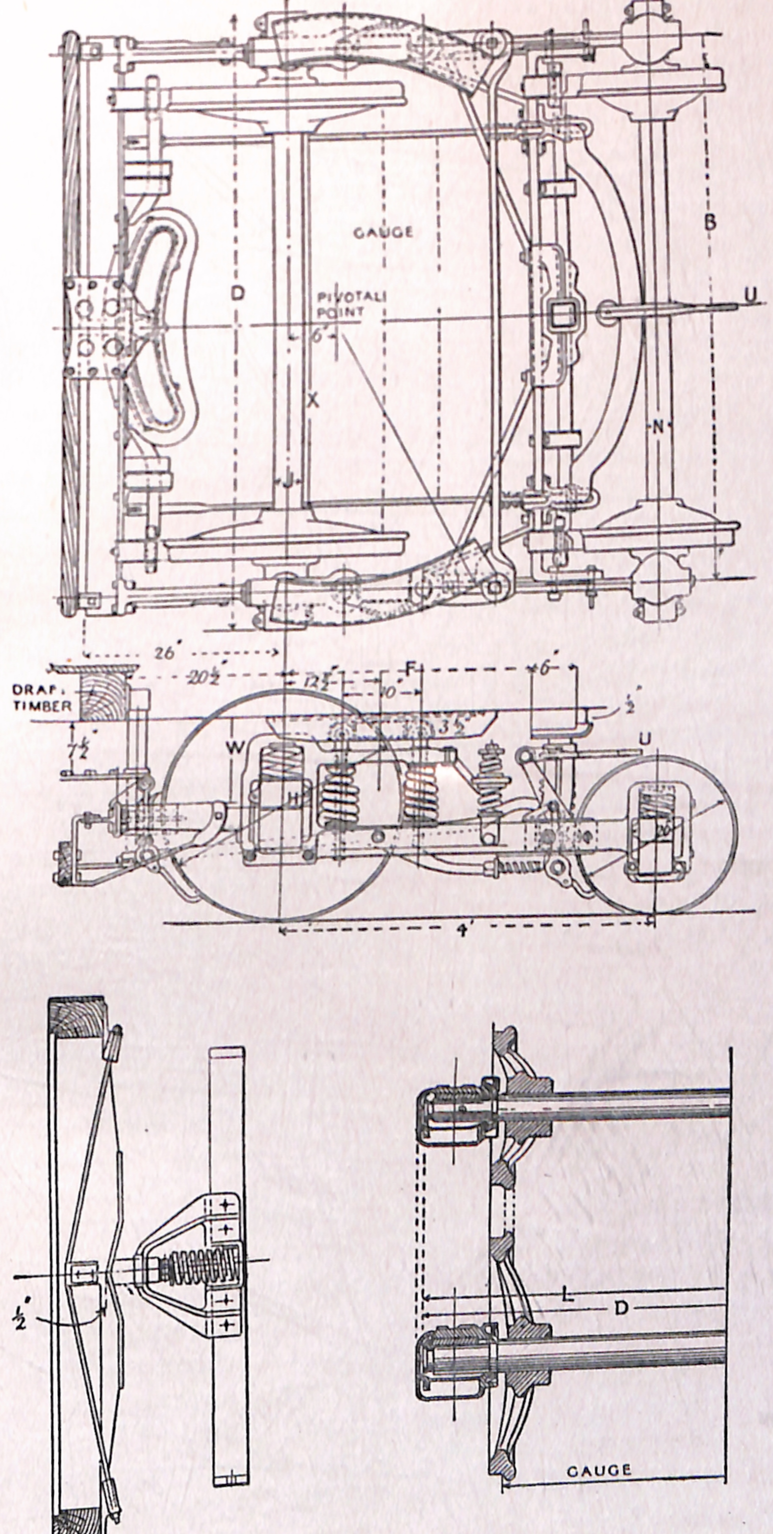

Fig. 238.—Brill Maximum-traction Truck

Equal-traction bogie trucks are specially adapted for heavy, long cars, where the conditions of service demand the extra horse-power obtained from four motors, or where the gradients prohibit the use of maximum-traction trucks. The traction is the maximum obtainable, owing to every wheel being a driving-wheel and bearing an equal share of the weight, and therefore can be classified in this respect with the four-wheel single truck. The use of four motors increases the acceleration of the cars and consequently the average speed, besides decreasing the losses from poor wheel adhesion.

Wheels and Axles.—Axles for electric cars are usually steel, but in some instances wrought iron is employed. The steel is usually cold-rolled, cold-drawn, or hammered; the former process is more generally employed. The body of the axles is mostly of $3\frac{3}{4}$ or 4 inches diameter, and the truck journals of 3 to $3\frac{1}{2}$ inches diameter. It is convenient to mill the gear keyway out before the wheels are pressed into position. Where end-thrust plates are not used, about $\frac{1}{2}$ inch from the extremity of each axle journal there is a recess of about $\frac{11}{16}$ inch by $\frac{1}{2}$ inch approximately for the reception of the thrust-plate of horse-shoe shape which slips into guides in the axle-box, and takes up both the forward and lateral thrusts. The weight of the car is taken entirely on the axle journals, and a saddle-shaped brass forms the bearing surface. In order to prevent dust getting into the axle-box a malleable-iron dust-collar is shrunk on to the axle near the outside boss of the wheel, and between this and the axle-box casting is generally placed a fibre ring. For driving axles the general practice is to machine them all over, but trailing or idle axles are only machined over the journals and wheel seats. The wheels are pressed on at a pressure of between 20 and 30 tons, care being taken to get the gauge-point of each wheel equidistant from the centre of the axle. The wheels should be pressed to a proper gauge-bar, sufficient accuracy being observed to ensure that they have not more than $\frac{1}{16}$ inch variation, this being the practical limit allowable in pressing wheels. The wheel gauge should vary from the track gauge by from $\frac{1}{4}$ to $\frac{3}{16}$ inch in order to give the necessary clearances. The usual diameter of wheels is from 28 to 33 inches, wheels of 30 inches diameter being the most popular in this country. They are usually made of cast iron, and in the casting are chilled around the flange to a depth of $\frac{3}{4}$ to $\frac{7}{8}$ inch. After the castings have set they are removed from the mould, and subjected to an annealing process in order to prevent uneven contraction and consequent internal strains. As a result of the chill the rims are so hard that they cannot be touched even by a file, so that any irregularity must be trimmed up by means of emery grinders. Cast-iron chilled wheels are liable to suffer from chipped flanges, more especially where the trackwork is bad, or where obstructions get into the rail groove, such as large-headed frost-nails, &c. The use of steel-tyred wheels is generally becoming more popular. The wheels are considerably more expensive, but will give a greater car mileage than cast iron. Again, they do not suffer to such a degree from chipped flanges, and take a better bite of the rail. The tyres are generally mounted on wrought-iron or cast-steel centres. In the case of disc centres, in order to avoid the ringing sound, these are broken up by several holes being introduced into the disc. The steel tyres are shrunk upon the centres, and are additionally held by set-screws. The centres and tyres are provided with shoulder and recess to ensure their taking up a proper relationship to one another, and also with a view of withstanding the side-thrusts to which they are subjected. A mileage of 20,000 to 50,000 miles, according to hardness and size, may be expected from tyres which from time to time require turning up in a lathe. An ultimate reduction in diameter usually specified is about $1\frac{3}{4}$ to 2 inches. With chilled cast-iron wheels we may expect a life of about 20,000 miles as an average minimum, and a reasonable estimate should be 25,000 to 30,000.

Car Fenders and Life-guards.—For the protection of the public, in recent years considerable attention has been paid to the provision of some device whereby persons falling or being knocked down in front of an electric or mechanically-propelled tram-car may be protected from serious harm.

We will only include mention of some of the best-known fenders which have, so far as we can tell, met with the Board of Trade approval during recent years.

Life-guards may be divided into three classes:—

(*a*) Those which project beyond the car itself.

(*b*) Those which are placed under the car platform, but which are without automatic action.

(*c*) Those placed under the car platform, and which are automatic in action.

(*a*) Of these guards the best known is the Providence fender, and in America it has become very popular. It is attached to the front of the car, and projects from there forwards and downwards till a few inches off the ground, forming a scoop in which obstructions may be caught up. In order to avoid injury to persons caught up, a spring buffer is provided, upon which they are received. The fender is constructed mostly of metal strips and rods attached to metal castings; the end of the guard is provided with rollers, so that when coming in contact with the roadway it does not buckle, but rides easily over it. The guard can be folded up when not in use.

A much similar guard to the above is the Dover life-guard. This is somewhat lighter in construction, and consequently cheaper to manufacture. In operation it is found to be very efficient, and projects to a less degree than the Providence. Its lightness and ease of detachment enable the use of only one per car, but if two are used the one not in use may be folded neatly up.

(*b*) This type is represented by the Peckham life-guard, which till quite recently was almost universally adopted. The Board of Trade inspectors have now more or less unanimously condemned this type. It therefore suffices to say that it consisted of a horizontal framework filled in with wire-netting forming a kind of tray, the sides of the frames being attached to the truck side frames and the fender being supported on springs attached to the truck tail-board or the car platform-bearers. A

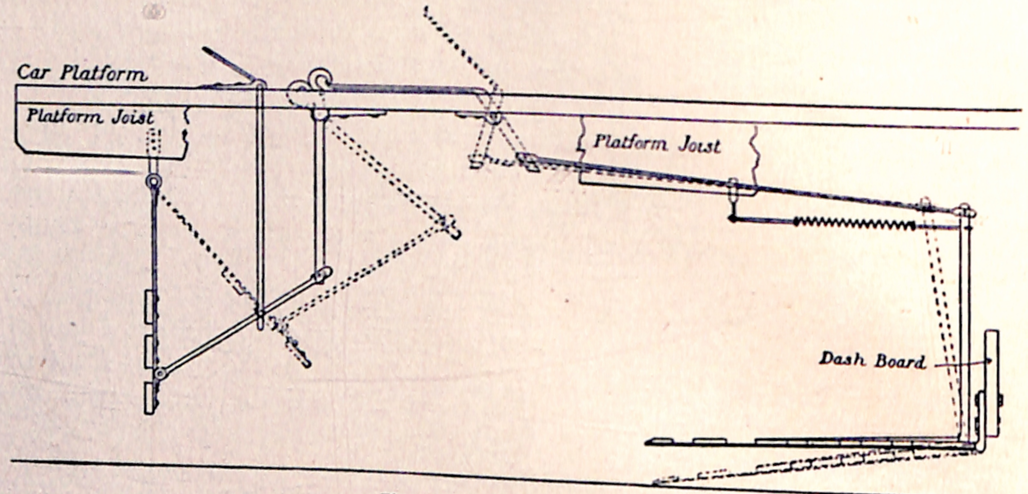

Fig. 239.—Tideswell Life-guard

wire screen was provided to prevent injury from contact with the tail-board.

(*c*) The best-known fenders of this class are the Wilson & Bennett, the Tideswell, and Hudson Bowring. Speaking generally, they operate on similar principles, and consist of guards placed under the platforms which

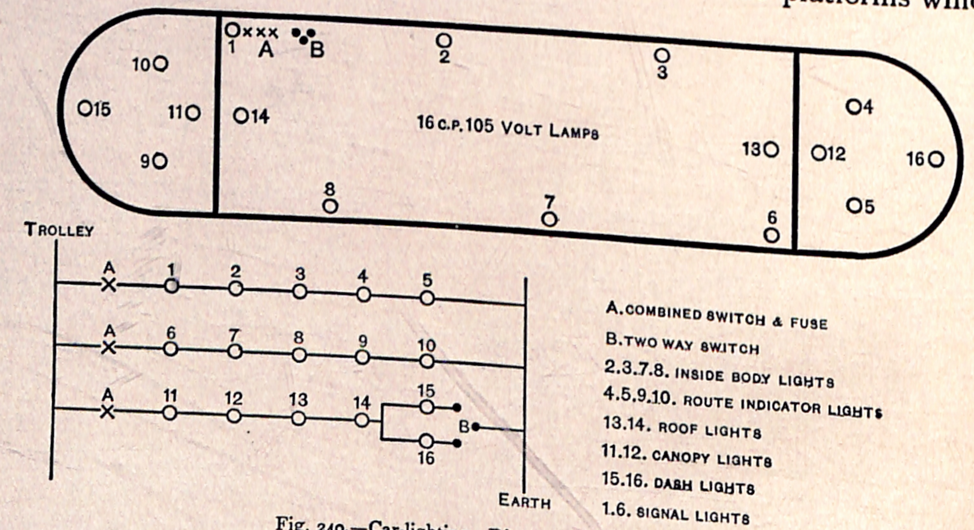

Fig. 240.—Car-lighting—Diagram of Connections

are lowered either by the motorman or by an object on the track coming into contact with a gate hung from the front portion of the platform. The Wilson & Bennett is constructed chiefly of metal, and is more expensive and complicated than the Tideswell, besides being of greater weight and strength. In operation these fenders have proved their

thorough efficiency. The Tideswell is built of wood laths and wrought and cast iron. The fender is illustrated in fig. 239.

Car-lighting Circuits.—In fig. 240 we give a useful diagram for double-deck car wiring. The wire used should be insulated with vulcanized rubber, heavily braided, of the 2500-megohm class. The size may be 3/22 S.W.G., which is amply large enough for one circuit. It is usual for car work that all fittings shall be provided with ⅜-inch brass thread nipples for the lampholders, which, contrary to American practice, where screw-socket holders are in general use, are of the bayonet-socket type, thus

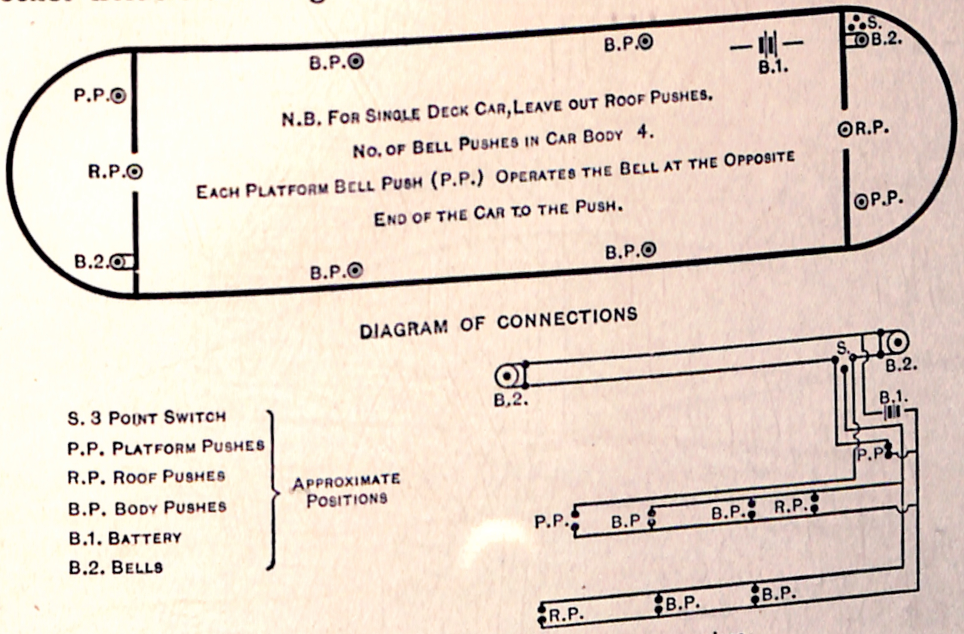

Fig. 241.—Electric-bell Wiring—Diagram of Connections

utilizing standard lamps, which, however, should be specially selected for series running.

Each circuit can be controlled by a small combined switch and cut-out, or by two separate devices. These should be capable of withstanding a dead earth anywhere on the circuit they control.

Bell Wiring.—We produce a diagram of a popular method of bell wiring for a double-deck car. The diagram is, we believe, quite self-explanatory (fig. 241). We favour single-stroke bells of the gravity type, as being less liable to get out of order, and more convenient for code signalling.

Official Publications.—For full information regarding any particular system the following in whole or in part should be consulted:—

1. The various Statutory Rules and Orders applicable to the system in question. (B.O.T.)

2. "Memorandum Regarding Details of Construction of New Lines and Equipment." (B.O.T.)

3. "Regulations made by the B.O.T. . . . for regulating the use of electrical power . . . &c." (Stationery Office, price One Penny.)

4. "Memorandum of requirements as to Railless Trolley Vehicles." (B.O.T.)

5. "Guard Wires on Electric Tramways, &c.", Explanatory Memorandum. (B.O.T.)

6. "Guard Wires on Railless Trolley Routes", Explanatory Memorandum. (B.O.T.)

7. "Post Office Circular, E. 17."

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