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The British Westinghouse Electric & Mfg. Co., Ltd.,

MANCHESTER AND LONDON.

Circular No. B 1113. December, 1906.

THE No. 220 TRAMWAY MOTOR.

The No. 220 Tramway Motor has been designed to meet the demand for a motor capable of a higher acceleration and greater schedule-speed than the well-known No. 200 motor. All details have been carefully worked out with a view to securing in this motor all electrical and mechanical characteristics essential to the utmost reliability of operation and freedom from repairs

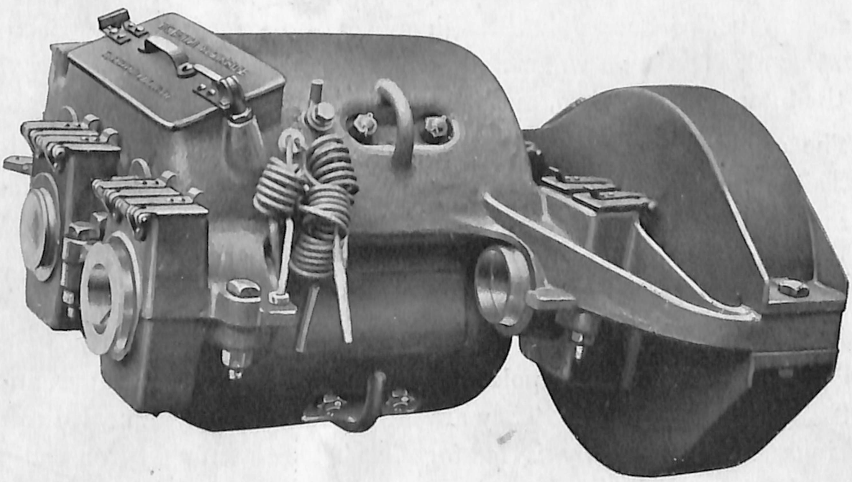

Fig. 1.—No. 220 Motor and Gear Case. (Front view.)

under the severest service conditions. The characteristic features which have rendered the operation of previous Westinghouse motors so successful under all conditions, have been preserved; and additional improvements—embodying the latest British tramway practice—have been added.

Constructional Details.

Field-Frame.—The field-frame of the No. 220 motor is of cast steel. It is almost octagonal in shape, with well-rounded corners, and is divided into an upper and lower half on a horizontal plane passing through the centre of the armature shaft. The two parts of the frame are hinged together on the side opposite to the axle (Fig. 2), and are securely held together on the opening side by means of bolts.

As shown in Fig. 5, the armature bearings are bolted to the upper half of the frame, and may easily be completely removed. The whole of the interior of the motor is thus easily accessible.

The commutator and brush-gear may be got at without disturbing the field-frame, a large opening being provided for this purpose directly over the commutator (Fig. 2). This opening is fitted with a felt-lined malleable-iron cover which is securely held by means of a cam locking-device so as to render the fixing watertight. The opening is at such an angle as to give a maximum amount of space for inspecting the commutator and brushes. The commutator is also accessible through a hand-hole, in the lower part of the frame, this also having a water-tight cover. The position of this, as viewed from the interior of the case, may be seen in Fig. 5.

The armature clearance may be inspected by means of two small sight holes, situated one at each end of the lower frame. One of these may be discerned in the bottom left-hand corner of Fig. 2.

All bolts are provided with an efficient locking device, in addition to a split pin.

Pole-Pieces.—The four pole-pieces project radially inwards at an angle of 45° with the horizontal. They are built up of carefully annealed soft-steel punchings, which are firmly riveted together between wrought-iron end-plates. Each pole-piece is fastened to the frame by two studs screwed into double nuts embedded in the punchings; these studs pass through the frame and are secured on the outside by nuts, lock-washers, and split-pins; these being sunk into a recess in the frame as seen in Figs. 1 and 2. The back face of each pole-piece is ground, and the portion of the frame against which it abuts accurately machined, so as to secure a good mechanical and magnetic joint.

The poles have projecting tips for furnishing the necessary commutating field, these also serving to hold the field coils in position.

Field-Coils.—The field-coils are wound upon formers in a winding lathe, and are thoroughly insulated with impregnated fibrous material. They are then heavily taped, after which they are subjected to a thorough dipping and drying process. Each coil is held securely in place by a brass support

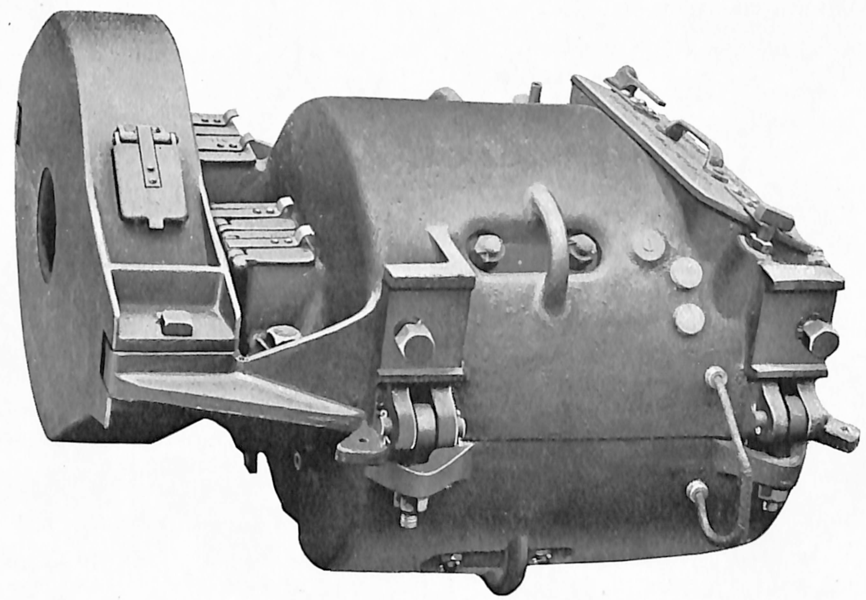

Fig. 2.—No. 220 Motor and Gear Case. (Back View.)

resting on the projecting laminated pole-tip, the coil being slipped over the back of the pole-piece before it is put in place. Flat steel springs are fixed between the coils and the frame to prevent vibration of the former.

Armature.—The armature is of the slotted-drum type, and, together with the commutator, is mounted on a spider which is rigidly keyed to the shaft. The core is built up of carefully-annealed soft-steel punchings of a high permeability, and its ventilation is provided for by six axial and one radial air-duct passing through it. The core teeth are supported and protected at each end of the coil by pressed-steel end-plates, which are toothed to correspond, and the whole is securely clamped between cast-iron end-plates.

Armature Coils.—These are formed to exact shape and size by being wound on wooden and fibre moulds. Each slot contains the halves of two separate coils, each of which is composed of three single coils, which are separately wound and insulated. The three single coils are bound together and insulated as a unit before being placed on the armature. The wire and other materials used in the manufacture of the coils are thoroughly dried before winding, and are afterwards put through a special process to ensure

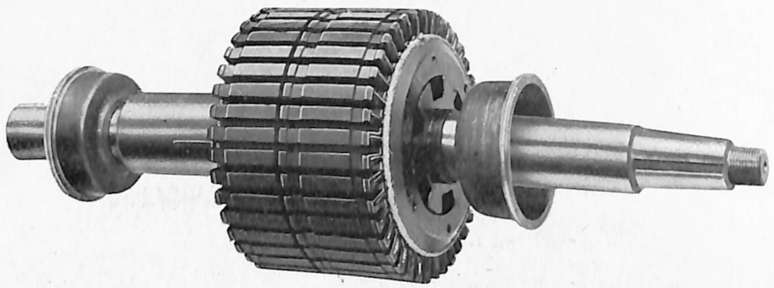

Fig. 3.—Spindle and Unwound Armature Core of No. 220 Motor.

perfect insulation. The shape of the coils and method of mounting them are such that hammering and bending are entirely avoided.

The coils are held in place by bands of steel wire, which are wound in grooves on the core, the grooves being of such a depth that the wires do not project above the surface. Thus the bands are not liable to be torn off in the event of the wear of the bearings allowing the armature to come into contact with the pole-pieces. The individual turns of the bands are well soldered together.

The armature winding is of the two-circuit type, and is such that a perfect balance of armature circuits is secured, even when the armature is considerably out of centre owing to the wear of the bearings. This system of connection is characteristic of all Westinghouse railway and tramway motors, and it is one of the features which contribute to sparkless running under all conditions of load.

Commutator.—The commutator is composed of 117 hard-drawn copper segments insulated from each other by strips of specially-prepared soft mica $\frac{1}{32}$nd of an inch thick. It has a diameter of $10\frac{1}{8}''$, a wearing surface $3\frac{1}{8}''$ long, and a wearing depth of $1''$. The segments, when assembled, are securely clamped to a cast-iron bush pressed on and keyed to the armature spider, thus preventing any movement relative to the armature core. The segments are thoroughly insulated from the shaft, and ample distance has been allowed to provide against leakage of current. Further, the great number of segments reduces the potential-drop between adjacent bars, thus favouring sparkless commutation.

Brush-Holders and Brushes.—The two brush-holders are made of cast bronze. Each is securely clamped to the motor frame with a $1''$ insulated

Fig. 4.—Armature of No. 220 Motor.

bolt, and they are capable of radial adjustment when it is necessary to follow up the wear of the commutator. This adjustment does not necessitate the dismantling of the brush-holder, and is effected by loosening a readily-accessible nut on the outside of the motor frame.

The carbon brushes are of the standard size, viz., $\frac{1}{2}'' \times 3'' \times 2\frac{3}{4}''$ long. Pressure is applied to the ends of each brush by two phosphor-bronze coiled springs, which are mounted a sufficient distance apart to ensure that the action of one shall be unaffected by the other. The pressure fingers are of drawn copper, and are securely riveted to the springs, which are of such a length that uniform pressure is maintained throughout the working limits of the carbon. Pins are provided for the springs to rest on when the carbon brush is being removed. Each brush-holder is thoroughly insulated from the motor frame by the insulated bolt already mentioned, and by vulcabeston blocks which have been treated to prevent the absorption of moisture.

Armature and Field Leads.—To avoid the use of metallic terminals in close proximity to the brush-holders, the ends of the field-coils and the armature leads are soldered directly to flexible rubber-insulated cables, several feet in length, which are brought out through insulating bushings of semi-soft rubber let into holes at the commutator end of the motor frame. Holes are drilled through the latter to enable the leads to be brought out either from the side next to the axle or from the side opposite, as may be desired; the spare holes being plugged up. The leads should be brought out from that side which will necessitate their least movement under the swivelling action of the truck when rounding curves.

Armature Bearings.—The dimensions of the bearings are such as to reduce the wear and liability to heat to a minimum. The armature-shaft bearings are $3\frac{1}{4}''$ in diameter, the length being $6\frac{3}{4}''$ at the commutator end, and $8\frac{1}{4}''$ at the pinion end. The bearings are of cast-iron, and the linings of special babbitt metal. The method of lubrication is notable, inasmuch as it allows of the use of either oil or grease, or both, at will. Extra large wiper rings entirely prevent the lubricant from finding its way along the shaft to the armature coils or the commutator. As will be seen in Figs. 1 and 2, two wells are provided for each bearing, these being for oil and grease respectively, and so marked. The covers of these are firmly held down by springs.

Axle Bearings.—The axle bearings are 9″ in length, and are arranged for an axle varying from $3\frac{3}{4}''$ to $4\frac{1}{2}''$ diameter (see p. 12). The size recommended is 4″. The bearings consist of cast-iron bushings lined with special babbitt metal, and are held between projections from the upper frame and cast-steel caps bolted thereto from below (Fig. 5). These caps being removable, the axle and wheels can readily be taken out. The method of lubrication is similar to that of the armature bearings, both oil and grease being provided for, and the respective reservoirs fitted with specially marked covers.

Gear-Wheel and Pinion.—The standard gear-wheel and pinion are each 5″ in width, and have machine-cut teeth. The pinion is of forged steel, and

is bored to fit the taper end of the shaft (Fig. 3), to which it is secured by a tight-fitting key, $1\frac{3}{4}''$ special hexagon nut, and lock washer. The end of the

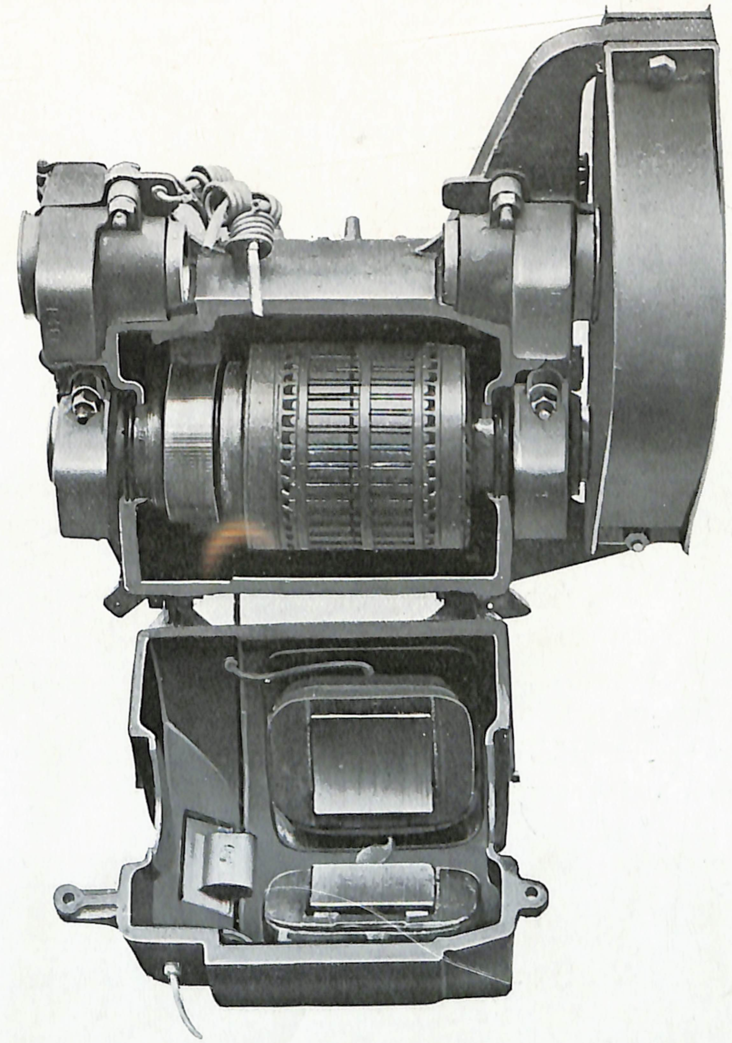

Fig. 5.—No. 220 Motor. (Field-frame open.)

pinion is counter-bored, so that the nut does not increase the overall length. The gear wheel is of cast steel, and is made in two parts, which are bolted together and keyed to the shaft. These halves are tongue-grooved, so as to prevent the teeth getting out of alignment.

The gear case is of malleable iron, and will accommodate any gear ratio from a 15-tooth pinion and a 70-tooth gear to a 22-tooth pinion and a 63-tooth gear; the standard gear ratio being 16 : 69. The gear case is in two parts, which are fastened to and supported on lugs forming portions of the upper half of the frame. The halves of the case are bolted to these lugs, and the support is such that there are no side or shearing strains. The lower half of the case may be removed without disturbing the upper half. A hand-hole with a spring cover is provided to facilitate the inspection and lubrication of the gears (Fig. 2).

Suspension.

The No. 220 motor is designed for cross-bar suspension. A rectangular suspension-bar is supported on the truck frame, and the motor is bolted to this through machined facings situated on the front of the upper field-frame, as seen in Fig. 2. These facings are provided with shoulders which rest on the top of the suspension bar, thus taking all the strain off the bolts. On the other side, the motor is supported on the gear-wheel axle in the usual way.

Approximate Weights.

	lbs.
Motor complete with Gear-Wheel and Gear-Case ...	2764
Armature and Pinion	540
Axle Gear-Wheel and Case	340

Gauge.

The minimum gauge to which this motor can be applied is approximately four feet, but it may be used with any wider gauge.

Clearance.

The clearance between the top of the tram rail and the lowest part of the motor is $2\frac{3}{8}''$ with 30″ wheels. No smaller wheel than 30″ should be used.

Rating.

The No. 220 motor has a nominal capacity of 42 H.P. In Fig. 6 are shown its approximate performance curves when working at 500 volts.

Power Required in Service.

The tractive force required to operate a car depends primarily upon its weight, upon the condition of the track, and upon the grade. In general it may be assumed that the tractive force required on a level track in reasonably good condition is 22·4 lbs. per ton weight of car. The tractive force on grades is equal to 22·4 lbs. per ton per % grade—*i.e.*, 22·4 lbs. per ton for each foot rise per 100 ft. of track.

$$\text{Thus:—T.F.} = 22{\cdot}4\ W + 22{\cdot}4\ Wg$$
$$= 22{\cdot}4\ W\ (1 + g)$$

Where T.F. is the total tractive force or effort, W the weight of the car in tons, and g the percentage grade.

For moderate speeds, *i.e.* not much exceeding 25 miles per hour, the tractive force is practically independent of the speed.

The H.P., of course, increases directly with the speed, and may be found from the formula:—

$$\text{H.P.} = \frac{\text{T.F.} \times \text{Speed in miles per hour}}{375}$$

The above only refers to the power required for running at constant speed. During the accelerating period, very heavy currents may be required, and this condition must be carefully considered when selecting a motor equipment.

The curves on page 10 will give a general idea of the capacity, speeds, &c. of the No. 220 motor.

The outline dimensional drawing of the motor in Fig. 7 gives the maximum and minimum diameters of axle for which it is suitable. For

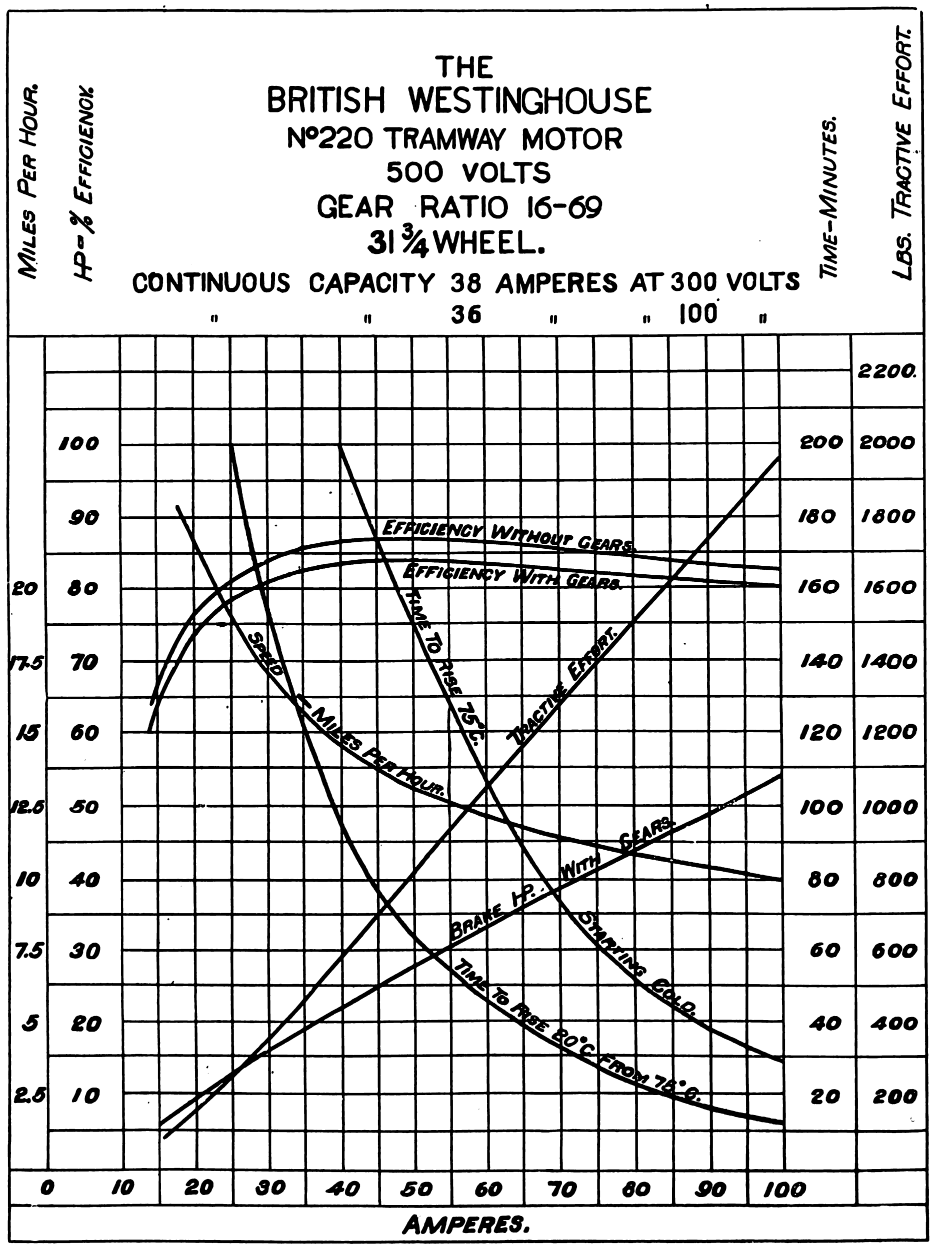

Fig. 6.—Performance Curves of No. 220 Motor.

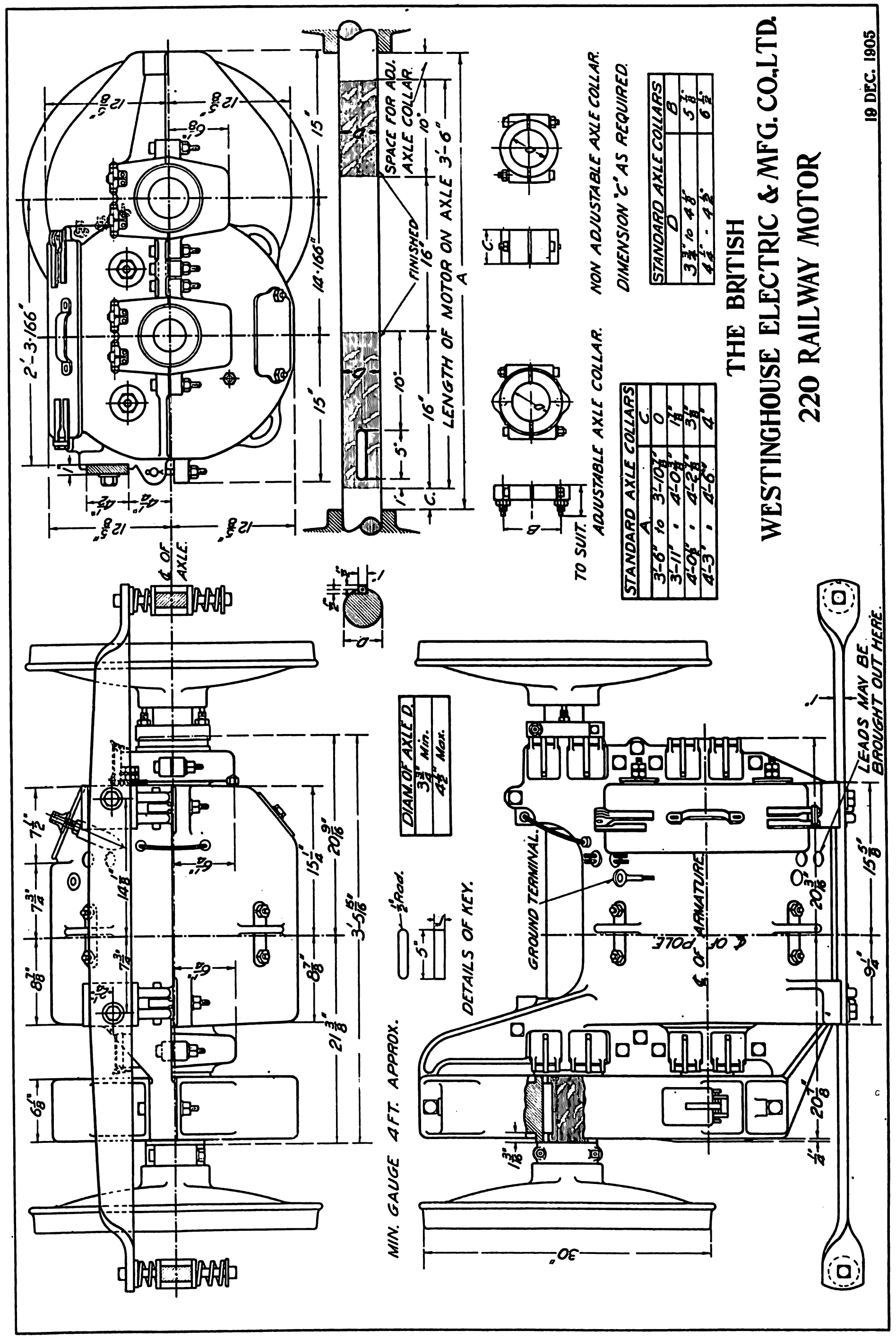

Fig. 7.—Dimensions of No. 220 Motor. (See also page 12.)

special cases the motor can be arranged for a maximum diameter axle of $4\frac{3}{4}''$ by special machining. The axle-collar dimensions are for axles varying from $3\frac{3}{4}''$ to $4\frac{1}{2}''$ in diameter.

The selection of the proper equipment for a given car and service is often a difficult problem, the successful solution of which may require a large amount of knowledge and experience. This being so, intending purchasers are invited to avail themselves of the services of the engineers of our Traction Department, who will be pleased to give their best advice on all such problems.

Westinghouse Works, Manchester, England.

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The British Westinghouse Electric & Mfg. Co., Ltd.

This Company operates in the British Empire (with the exception of Canada), and in Norway and Sweden.

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