direct current motors. The commutation of the motors is so good that no more attention to the brushes and commutator is required than with low voltage motors of similar capacity. As the motors have the same electrical characteristics as other direct current motors, the armature speeds are no greater, and in consequence the bearings are equally long lived.

Some motors have been furnished by the General Electric Company for operating directly on 1,200 volts and others two in series. With the former it is possible to operate at only half speed on 600-volt portions of the line, but the latter motors can be connected in multiple so as to give the same speed on the low voltage as the high, which in many cases is a great advantage.

The car equipment consists of apparatus similar to that used for 600 volts, many of the parts being identical. Cylinder platform controllers have not been used in any instance, however, as they require the motor current to be carried above the floor, and we have considered it advisable for obvious reasons to keep the apparatus that breaks the main circuit under the car, where it can be suitably isolated.

Sprague-General Electric Type M control, comprising electrically operated contactors, a reverser and a circuit breaker is used. These parts are practically the same as for 600 volts with additional insulation where required. Both automatic control as described in my paper of last year for 600-volt operation and hand, or non-automatic, control have been furnished. The circuit connections are identical, for both the master control and the motors, to that used for 600 volts.

Standard 600-volt contactors, operated by means of electro-magnets, are employed for making the motor and resistance circuits in the contactor box, a few extra contactors being used to provide the necessary breaks in series to safely open the circuit. Practice has shown that a 1,200-volt current can be very satisfactorily interrupted by the contactors, and that the burning is not excessive.

Proper insulation of the reverser contacts is easily secured, owing to the motor fields being reversed, instead of the armatures when the direction of car movement is to be changed, and also because the fields are connected to the ground side of the armatures. This connection of the motors has been adopted both in new cylinder controllers and type M control for 600 volts. For commutating pole motors, it is desirable, in order that the commutating field winding, which is permanently connected to one side of the armature may always be on the ground side of the armature. The connection has also the advantage that fewer of the contacts have a high potential between them, as the drop across the exciting field to be reversed is only about fifteen volts.

A magnetic blow-out circuit breaker, located under the car, similar to the one generally furnished with type M control, is used for an overload protective device. It is, however, provided with a more powerful magnetic blow-out and has an increased opening and insulation. The circuit breaker is set and tripped from the motorman's cab by means of the ordinary double-movement switch which connects to the proper train wires.

A magnetic blow-out copper ribbon fuse box is provided as an additional protective feature for the main circuit. Standard 600-volt cast-grid rheostats are used for providing the necessary resistance steps in starting the motors. These rheostats are effectually insulated from the angle-irons to which they are attached by means of large collars and tubes surrounding the supporting bolts. A new design of cast-grid rheostat has recently been brought out.

When a car equipped with four motors is required to operate at the same speed on both 600 and 1,200-volt sections, it is necessary to use a commutating switch for changing the connections of the motors. For 1,200-volt operation this switch connects the motors in two groups with the motors in each group in series, each group being handled as a single motor. This commutating switch is arranged for operating either by hand or with air controlled by a valve located near the motorman. An interlock device is provided which prevents operation of the contactors if the motors are not properly connected for 1,200-volt running.

On some roads the operating conditions are such that only on the interurban sections is it desirable to obtain the maximum speed. To meet these requirements the commutating switch is, therefore, not necessary, and having 1,200 volts on the high-speed section and 600 volts on the city division gives relative speeds of about 2 to 1.

Six hundred-volt current is used for operating the control, and also for the car lighting. With the earlier equipments the air compressors are also operated at this voltage. This current is obtained from a dynamotor, or motor generator, of waterproof design for mounting under the car.

The new feature of the dynamotor is a series field winding which is connected between the two halves of the armature, and is provided with a tap at its centre. In starting up, line current passes through the first half of armature, series field, and second half of armature to ground, thereby strengthening the normal field, and the machine operates as a compound motor. When current is being taken from the tap in the centre of the series winding for the control of lights, the two halves oppose each other, and there is no effect on the field strength. When the trolley leaves the wire with the dynamotor running, and the controller on, there is an immediate tendency of the dynamotor to deliver current to the motors, due to the momentum of the armature and the shunt field. The series winding now comes into play by demagnetizing, or beating down, the field, since the direction of the current has been reversed in the first half of the series field, and the two parts, therefore, no longer oppose each other. This action prevents an amount of current sufficient to blow the dynamotor fuse being taken by the motors.

The dynamotor is a very simple device, both electrically and mechanically. No mechanical load being driven by the armature, the strains on the bearings are negligible and the parts are long-lived. On recent equipments the dynamotor is started up automatically, when the car runs on to a 1,200-volt section, by means of a selector relay. The light and control circuits are disconnected from both the trolley and dynamotor when the relay is not energized, the proper connections being made to correspond with the voltage applied. To insure correct operation of this relay, a short, grounded section of trolley wire is interposed between the 1,200 and 600-volt portions.

The electric heaters can be operated either from the dynamotor or directly from the 1,200-volt circuit. As the conductors in the heater are insulated from the frame by porcelain, the requisite insulation is easily secured for 1,200-volt operation.

The air compressors on some recent equipments are wound for operating at 1,200 volts, as there is no difficulty in obtaining good commutation and insulation for this voltage. When the car is running on the 600-volt section the compressor will, of course, be required to operate for a longer period if air is used to the same extent as on the 1,200-volt portion, but this is easily taken care of in selecting the proper capacity of compressor.