was extended so as to afford more protection to the parts inside, and finally it was made in two bowl-shaped halves, completely enclosing the armature and fields, which is the style standard to-day for moderate sized machines of all makers. The field poles are cast as part of the frame, or sometimes cast steel machined separately and bolted to place; again there is the laminated type, either with the frame cast round them or held in position by bolts; as compared with the solid pole this construction produces a lighter machine for a given output, and one somewhat more efficient. In this totally enclosed type of case the ventilation is practically nil; on elevated systems and in some interurban roads advantage is taken of the comparative absence of dust and dampness to put openings in the frames which, partially closed by screens, allow more or less air to circulate through the windings.

The lubrication of all moderate size motors is by means of grease, held in pockets cast in the frame over the bearings; these latter are generally outside the machine proper, being provided with channels underneath so that any overflow or drippings are thrown outside, lubricants of all descriptions being fatal to good insulation. Occasionally there is provided an auxiliary oiling wick underneath the bearing, the grease then being more or less of a reserve intended to be used only if the journal gets hot, in which event it melts and thus provides extra lubrication. On the heavier motors for elevated works, oil is depended upon almost entirely, though it has the disadvantage of causing much more drip than the greases.

The foregoing covers the general outline of the standard moderate sized street railway motor of to-day; there naturally are many modifications, such as the type in which the frame, instead of being split horizontally, is cast in one piece, cylindrical in form, the armature and fields being removed through openings in the ends, normally filled by cast iron shields carrying the bearings; there is also the gearless motor, a type which has found much more favor on the continent than it has over here, though it should be noted that the Baltimore and Ohio locomotives, the largest electric traction machines ever built, weighing nearly 100 tons each, are of this type.

Equally a curiosity, at any rate on this continent, is the alternating traction motor, though it has been used to some extent in Europe; those built over here follow to a great extent the general lines of the D.C. machines, except of course in their internal arrangements. It should be observed that they can be run in series parallel, the armature of one machine supplying the fields of the next, somewhat similarly to the standard series parallel controller.

All street railway motors to-day are series wound, that is, the same current after passing through the armature goes on through the field coils, or vice versa. Shunt machines are unsuitable for several reasons, one is that being essentially constant speed apparatus they would tend to drive the car at the same rate irrespective of the load or the grade. In climbing hills this would result in a greater current consumption than the motors could stand, on the other hand the series motor slows down with an increase in load, and consequently takes less current than would be needed if the same speed were maintained.

The field coils are sometimes connected in front of the armature, in which case they are said to act as a choking coil, and to thus lessen the chances of lightning damaging the latter; in other systems they are connected next to the ground in order to lessen the chances of trouble in themselves. If wired in this manner, when the motors are in parallel the maximum potential between the fields and ground is about 30 volts, when they are in series this is increased on no. 1 machine to 250 volts, no. 2 remaining as before.

The next point to be considered is the method of using the motors as an emegency brake. If the motors are driven by some outside force, such as momentum or gravity, they tend to generate current the same as any other dynamo, and if the connections of the field be reversed with respect to the armature, they will gradually produce more and more voltage, or build up, as it is termed. Further, if they now be connected in parallel, any slight difference in voltage between the two will start a current flowing which still further changes the field strengths and thus produces an increase in the current. This means that one machine becomes a generator with a heavy load, which tends to pull it up, this in turn through the gears tending to stop the car. The other machine becomes a motor with a heavy current forced through it and consequently a heavy torque, but being reversed instead of tending to drive the car forward, as does current from the trolley wire, this tends to drive the car backwards. It will thus be seen that the action of both machines is to stop the car, which will pull up quite sharply. Now, as soon as this has taken place the current ceases, and if the car be on a down grade it will immediately start again, and after it attains some slight speed the process will repeat itself; it is thus possible to take a car down hill without the aid of either brakes or current from the trolley wire. It should be noted that this method of stopping is quite distinct from that of using the main current with the machines reversed; further, that on a two motor controller the throwing of the reversing switch does not put the motors in parallel, they can only be connected in this way by means of the main cylinder which has to be turned to some one of the parallel positions, which is immaterial; with the current breaker open or the trolley off there is no closed circuit on any of the series steps. On the other hand, with a four motor controller, there being two pairs of machines permanently in parallel (except when equipped with a commutating switch set for series connection), all that is necessary to obtain the desired connection is to throw the reverse handle. Occasionally there are found two motors which are so nearly alike, or give results so closely allied that this action will not take place, though it is probable that 99 per cent. of the cars in service to-day will act as described above.

The foregoing covers, in outline only, the principal parts comprising the modern electric car equipment of medium capacity; it is obviously impossible, within the limits of this paper, to go to any extent into detail; there remains but to glance at its general properties compared with electrical apparatus designed for radically different service.

Compared with commercial stationary direct current machines having about the same armature speed, we find that the street railway motor, horse power for horse power, weighs somewhat less than half as much as does the former, direct current machines of the lower speeds averaging 110 to 135 lbs. per h.p.; the street railway motor somewhere about 65. You must further note that the latter machine has a momentary maximum output of two or three times its normal capacity, that is, a machine rated at 30 h.p., according to the methods adopted by standard practice to-day, will for short periods give an output of 80 to 100 h.p., in fact there is to-day no other machine which, weighing but one ton and contained within the three dimensions of about 30 inches, will produce from 25 to 50 h.p. and this with a high degree of economy; obviously this result is obtained only by having a machine of the greatest simplicity composed of the very finest materials obtainable and built with the utmost attention to every detail.

Further, it is to be observed that some of the machines made for this purpose are by no means small. The first cars put into service were equipped with two motors of about 12 to 15 h.p., each weighing in the neighborhood of 2,300 pounds; to-day the ordinary car in city service has two 35 or 40 h.p. motors, weighing with the controlling mechanism about 3½ tons, the complete car averaging about 12 tons. The average car on interurban high speed service, equipped some with two motors and some with four, varying from 50 to 80 h.p. each, will weigh somewhere in the neighborhood of 25 tons, 8 to 12 tons of this being accounted for by the 200 to 300 h.p. of electrical equipment with which they are provided. Cars for elevated roads will average somewhere about 30 tons each, and as they are frequently run in trains of two or three, the complete outfit will weigh in the neighborhood of 100 tons. The Baltimore and Ohio Railway Company's locomotives are the largest electrical traction machines in use to-day; they weigh about 100 tons each, the motors, of which there are four, being rated at 325 h.p. each, the normal current input of the complete machine reaching the large total of 2,000 amperes.

It is obvious that, having such a fine equipment as the modern railway motor, we should make every effort to keep it in good shape, to get from it the maximum of service with the minimum of cost and to maintain a schedule free from the most annoying of troubles, road breakdowns. One of the most essential points to this end is a thorough system of inspection; without some such procedure it is hopeless to expect anything but that the repair accounts will be unduly large, and your customers far from satisfied with the service they receive. It is usual in modern railway practice to have two and sometimes three distinct times of inspection for each car, every road having a night man who makes a visual and more or less superficial examination each night, and a barn repair crew who dismantle and thoroughly overhaul every equipment at stated intervals of 6 to 12 or 14 weeks. To these some roads add the day inspector who visits each car when in service, examining the operation of the commutators and the controllers, and receiving reports from the crews as to any incipient defects which they know should receive attention.

The greatest aid to such a system of inspection, and in fact a prime necessity of its existence, is a set of books, as simple as possible, but nevertheless complete in that they show the date of every operation, both day and night, on each car, and the names of the men performing them. From records such as these you will be able to determine and accurately keep track of the date on which any car is due to come in for general overhauling. Having determined, from the class of equipment and the amount of work it has to do, the safe running limits of the machines, that is, the longest time which it is practicable to leave them on the road and still not run into danger of having breakdowns, it is highly desirable to keep the system in such shape that the cars come in very close to the periods set for them. Such a system as this, apart from lessening the cost of repairs and reducing the number of street breakdowns, has great value in another direction, namely, the question of damage suits. Accidents, as we have all been told so many times, will happen; happy is the man who, in the hour of trial, can produce complete records and show that the car equipment in question was inspected and overhauled on a certain specified date by men competent and familiar with this class of work, and pronounced by them to be in thorough workmanlike condition; he has gone far towards acquitting his company of that bugbear and foundation for so many claims, alleged negligence.

[NOTE.—The foregoing paper was present-